U.S. Fish and Wildlife Service
Office of Subsistence Management
Fisheries Resource Monitoring Program

Spawning Distribution and Run Timing of Copper River Sockeye Salmon, 2005 Annual Report

Annual Report for Study 05-501

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March 2006

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ABSTRACT

The purpose of this three-year (2005-07) project was to use radiotelemetry techniques to assess the spawning distribution and run timing for adult sockeye salmon *Oncorhynchus nerka* stocks in the Copper River, Alaska. This report summarizes the results from the 2005 field season. Specific objectives were to: (1) estimate the proportions of sockeye salmon returning to major spawning areas of the Copper River (Lower Copper, Chitina, Tonsina, Klutina, Tazlina, Gulkana and Upper Copper rivers) such that the proportions were within 10% of the true proportions 95% of the time; and (2) describe the stock-specific, migratory timing profile of sockeye salmon in the Copper River at the point of capture in Baird Canyon. The largest proportion of spawners returned to the Klutina River drainage (0.35), followed by the Upper Copper (0.28), Tazlina (0.12), Lower Copper (0.07), Gulkana (0.07), Chitina (0.05), and Tonsina (0.05) rivers. Run-timing patterns at the capture site varied among stocks. The mean date of passage at Baird Canyon varied from 31 May for the Tazlina stock to 13 July for the Tonsina stock.

Citation: Smith, J. J., G. Wade, K. M. van den Broek, and J. W. Savereide. 2006. Spawning distribution and run timing of Copper River sockeye salmon, 2005 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 05-501), Anchorage, Alaska.

INTRODUCTION

Copper River sockeye salmon *Oncorhynchus nerka* support large and important commercial, subsistence, sport, and personal-use fisheries in Southcentral Alaska. Sockeye salmon stocks are widely distributed and known to be present in approximately 125 Copper River tributaries (Roberson 1987; Taube 2002). Harvest is significant in comparison to abundance, and sockeye salmon are the most utilized species for subsistence users. Management of Copper River sockeye salmon has become increasingly complex due to the interplay of federal and state management of a gauntlet of fisheries (commercial, sport, subsistence, personal use), fisheries that target a mixture of species and stocks, inter-annual variation in the size and timing of stocks, difficulties in estimating abundance due to the physical characteristics of the drainage, and the inability of current management tools such as the Miles Lake sonar to allow species apportionment. To compound these difficulties, stock-specific run-timing and spawning distribution information is either limited or extremely dated. As a result, Copper River sockeye salmon were recently identified as the highest priority for Federal subsistence management information needs.

Management of Copper River salmon is complex in that there is both Federal jurisdiction of subsistence fisheries on Federal public lands; and State jurisdiction of commercial, sport, and subsistence fisheries throughout the drainage (Appendix A.1; Buklis 2002). State fisheries are managed under guidelines established in fishery management plans by the Alaska Board of Fisheries (BOF). Under the Copper River District Salmon Management Plan (5 AAC 24.360), the Alaska Department of Fish and Game (ADF&G) currently manages the Copper River District commercial salmon fishery to achieve a sustainable escapement goal of 300,000 – 500,000 sockeye salmon into the Copper River (AAC 2004). This includes a spawning escapement of 300,000 sockeye, a subsistence component of 160,000 – 225,000 salmon, a sport fishery component of 15,000 salmon, as well as brood and surplus fish to the Gulkana Hatchery that are estimated annually.

ADF&G uses a combination of fishery performance statistics and estimates of sockeye salmon entering the river to make decisions on whether and for how long to open the weekly fishery. Estimates of fish escaping the commercial fishery have been made using sonar counts at a site near the outlet of Miles Lake. An estimated 854,268 salmon passed the Miles Lake sonar site between 9 May and 31 July 2005. In addition, a test fishing project at Flag Point Channel in the lower Copper River has been used to index salmon abundance from 2001-2004 (Link et al. 2001a; Lambert et al. 2003; Degan et al. 2004; Mueller and Degan 2005). The information provided from this project is taken into consideration by fishery managers who make decisions regarding commercial openings.

Three major stock components of sockeye salmon return to the Copper River each year (Ashe and Taube 2002). The Upper Copper River wild stock component is the most abundant component and it consists of both early and late returns, all of which spawn in tributaries above Miles Lake. Major spawning tributaries in the Upper Copper River include the Chitina, Tonsina, Klutina, Tazlina, Gulkana and Slana rivers (Merritt and Roberson 1986). The second component is composed of enhanced sockeye salmon which are produced from the Gulkana Hatchery, and their run timing overlaps with the late-run (upper river) wild stock component. Lower delta stocks, which make up the third component, spawn in systems below the Chugach Mountains between Eyak Lake and the Katalla River. Sockeye salmon stocks begin to enter the Copper River in early to mid May, as rising temperatures and water flush the ice from the river, and nearly all have entered the river by early to mid August.

The majority of Copper River sockeye salmon are harvested in a commercial gill net fishery located in the Copper River District (a designated commercial fishing area in and around the mouth of the Copper River) from mid May through August. An average of 1,138,000 sockeye salmon were harvested annually in the Copper River District from 2000 through 2004 (Ashe et al. 2005). In 2005, 1,332,000 sockeye salmon were harvested, the seventh largest harvest since 1974 (ADF&G 2006).

Federal subsistence fisheries for sockeye salmon are open from approximately 15 May to 30 September in the Upper Copper River District. This area is comprised of two main subdistricts: 1) the Chitina Subdistrict – waters of the mainstem Copper River from the downstream edge of the Chitina-McCarthy Bridge downstream to an east-west line crossing the Copper River approximately 183 m (200 yards) upstream of Haley Creek; and 2) the Glennallen Subdistrict – waters of the mainstem Copper River from the mouth of the Slana River downstream to the Chitina-McCarthy Bridge. Subsistence fishing also occurs in the Batzulnetas area.

The State subsistence fishery is open from approximately 1 June to 30 September in the Glennallen Subdistrict. Sockeye salmon are also harvested in the personal-use, Chitina Subdistrict dip net (CSDN) fishery which is open from approximately 1 June to 30 September. In 2004, reported harvests of sockeye salmon in the Glennallen and Chitina subdistricts were 52,130 and 93,182 fish, respectively (Ashe et al. 2005).

Sport fishing (rod and reel) for sockeye salmon is open throughout most of the Copper River drainage; however, fishing effort is focused mainly in tributaries of the Upper Copper River such as the Gulkana and Klutina rivers. From 2000 to 2004, sport harvest of Copper River sockeye salmon ranged from 6,464 (2004) to 12,361 (2000) fish and averaged 8,373 fish (Hollowell and Taube 2005).

Early work on characterizing the run timing and distribution of sockeye salmon on the Copper River was limited and has become somewhat out of date. Merritt and Roberson (1986) examined sockeye salmon run-timing patterns on the Copper River. Their analysis was based on tag recoveries obtained during mark-recapture experiments done from 1967 to 1972, however, these recoveries had been obtained from non-systematic sampling of tributary stocks. Fish spawning in areas or at times where they were difficult or impossible to physically recover were not systematically sampled. (For example, fish spawning in mainstem locations were not recovered and hence, their run timing was not characterized.) Since the early 1970s, the inriver abundance and characteristics of the entire Copper River stock complex have changed. The Gulkana hatchery began producing large numbers of fish in the mid 1980s, different fisheries have expanded or contracted, and environmental and river conditions have varied. Finally, run timing information from Merritt and Roberson (1986) was based on tags applied at Wood Canyon and run timing at the entry to the Copper River had to be inferred from limited tags applied near Miles Lake.

The purpose of this study was to use radiotelemetry techniques to provide accurate and up-to-date information on the run timing and spawning distribution of Copper River sockeye salmon stocks. These data will increase our understanding of the relationship between fish passage at Miles Lake and subsequent weekly abundance through the inriver fisheries, as well as provide fishery managers with additional information that can be used to better manage the fishery and ensure that escapement goals are met.

Objectives

Objectives for the 2005 study were to:

1) Estimate the proportions of sockeye salmon returning to the major spawning tributaries of the Copper River (Lower Copper, Chitina, Tonsina, Klutina, Tazlina, Gulkana and Upper Copper rivers) such that the proportions are within 10% of the true proportions 95% of the time; and

2) Describe the stock-specific, migratory timing profiles of sockeye salmon in the Copper River at the point of capture in Baird Canyon from 2005 through 2007.

To achieve these objectives, approximately 500 adult sockeye salmon were radio tagged in 2005 at three fishwheels located in Baird Canyon (rkm 69) and tracked throughout the basin using a combination of fixed tracking stations and aerial-tracking surveys (Figure 1). This project was integrated with two other studies being conducted by the Native Village of Eyak (NVE): 1) an OSM-funded project (FIS04-503) to estimate the annual timing and abundance of Chinook salmon *O. tshawytscha* upstream of Baird Canyon; and 2) an ADF&G (2005-06) and OSM-funded (2006; FIS06-502) project to estimate the annual abundance of sockeye salmon returning to the Copper River.

Study Area

The Copper River drains an area of more than 62,100 km^2 (24,000 mi^2), flows southward through south-central Alaska, and enters the Gulf of Alaska near the town of Cordova (Figure 1). Between the ocean and Miles Lake (rkm 48), the river channel traverses the Copper River Delta which is a large, highly braided, alluvial flood plain. A relatively high proportion of the Copper River's headwaters are glaciated which results in very high unit discharge (volume per square kilometer of drainage area) and sediment loads (Brabets 1997). From 1988 to 1995, the annual mean discharge on the lower Copper River was 1,625 m^3/s (57,400 ft^3/s), with the majority of flow occurring during the summer months from snowmelt, rainfall and glacier melt (Brabets 1997). Peak discharge in June ranged from 3,650 to 4,235 m^3/s while annual peak discharge ranged from 6,681 to 11,750 m^3/s. Water levels in Baird Canyon typically rise sharply from late May through June, level off in July, and then peak in August. Sediment loads cause the water to be unusually turbid and fill the river with numerous ephemeral sandbars and channel braids for most of its length.

METHODS

Capture and Tagging

Fishwheel Design and Operation

Adult sockeye salmon were captured using three live-capture fishwheels that operated on both banks of the mainstem Copper River at Baird Canyon (rkm 69-71) in 2005. Two of the fishwheels (fishwheels 1 and 2) consisted of two, welded-aluminum pontoons (11.6 x 0.9 x 0.5 m), three large baskets (3.0 x 3.0 x 2.1 m) constructed with aluminum tubing (3.8 cm square), and one aluminum live tank (4.3 x 1.5 x 0.6 m) fitted inside each pontoon that held captured fish (Photo 1). The third fishwheel at Baird Canyon (fishwheel 5) was smaller than the other two fishwheels (Photo 2). Fishwheel 5 was constructed from two, welded-aluminum pontoons (10.3 x 0.7 x 0.4 m), four wooden baskets (2.1 x 1.8 x 0.8 m), and two live tanks (4.6 x 0.6 x 0.9 m). The baskets for all three fishwheels were lined with knotless nylon mesh (6.4-cm stretch).

The fishwheels were installed and operated similar to the methods used in previous years (Link et al. 2001b; Smith et al. 2003; Smith 2004; Smith et al. 2005; Smith and van den Broek 2005). The fishwheels were operated 24 hours per day, except for stoppages when they were being re-positioned or repaired. Daily water level was measured from a staff gauge secured to a rock wall on the east bank of Baird Canyon.

The Baird Canyon fishwheels were also used to capture adult Chinook salmon for a separate mark-recapture study (Smith and van den Broek 2006). In order to reduce the potential for overcrowding of fish in the live tanks, which may contribute to increased stress on sampled Chinook salmon, escape panels were used in the live tanks of all three fishwheels in 2005. The escape panels consisted of two, adjustable vertical slots in a removable aluminum frame (see Photo 6 on p. 84 in Smith et al. 2003). When installed and opened to the appropriate width (6 to 7.5 cm), the escape panels allow smaller fish such as sockeye salmon and other by-catch species to easily swim out of the live tanks while retaining Chinook salmon. As a result, the escape panels reduce overcrowding and the potential for sampling mortalities during high-catch periods as well as the amount of crew labor for handling fish. However, to ensure that radio-tagged sockeye salmon for this study were not biased by size, only fish captured during periods when the escape panels were closed were sampled. Catch per unit effort (CPUE, fish per hour) was calculated by dividing the total number of sockeye captured while the escape panels were closed by the length of time the escape panels were closed.

Tag Application

A systematic approach was taken to ensure that radio tags were deployed in proportion to the magnitude and timing of the sockeye salmon run (so that fish from all stocks had an equal probability of being tagged). A schedule for deploying the 500 radio tags was drafted prior to the field season using a preseason forecast for Copper River sockeye salmon that was provided by ADF&G fishery managers in Cordova (S. Moffitt, ADF&G, Cordova, pers. comm.). The tagging schedule was adjusted inseason based on daily salmon counts at the Miles Lake sonar site and the number of radio tags remaining.

Only a small portion of the sockeye salmon captured in the fishwheels each day were radio-tagged. Tags were deployed in a manner that would reduce the potential of bias from factors such as day of the week, time of day, bank of deployment, fish size, and gender. For example, the crew alternated daily between banks (east/west) and time of day (morning/evening) when collecting fish for sampling. To obtain fish for tagging each day, a live tank in one of the fishwheels was emptied following either the morning (~0830 hours) or afternoon (~1500 hours) sampling period. The fishwheel was then operated for a specified period, typically until the crew returned to the fishwheel for the next scheduled fishwheel visit, and all fish captured in the live tank were retained. During the next sampling session, sockeye salmon were randomly selected from the live tank and radio-tagged. Once the daily tag quota was met, the remaining sockeye salmon were counted and released. The escape panel in that live tank was then re-opened.

Using a dip net, healthy sockeye salmon were transferred from the live tanks to a water-filled, foam-lined trough for sampling. Radio tags were inserted orally into the upper stomach of the fish using a 20-cm long piece of plastic tubing (Photo 3). The whip antenna of the radio tag was left protruding from the mouth of the fish. No secondary mark was applied to radio-tagged fish. All radio-tagged fish were measured for fork length (mm FL) from the tip of the snout to the fork of the tail and sexed from external characteristics.

Tracking Equipment and Procedures

Tags

Radio tags were Model F1840 pulse-encoded transmitters made by Advanced Telemetry Systems, Inc. (ATS; Isanti, MN). Each radio tag was distinguishable by a specific frequency and pulse-encoded pattern. We used twenty frequencies ranging from 148.025 to 148.404 MHz that were spaced approximately 20 kHz apart with 25 encoded pulse patterns per frequency (500 tags total). The tags were 17 x 51 x 15 mm, weighed 20 g each, and contained lithium batteries with a warranted life of 169 days (battery capacity of 339 d). The tags had a pulse rate of 45.8 ppm, a pulse width of 34 ms, and a current drain 0.203 ma. Each tag had NVE's address printed on the side so that if tagged fish were captured in an inriver fishery it could be returned and potentially re-deployed at Baird Canyon.

Tracking Stations

Radio-tagged sockeye salmon were tracked throughout the Copper River drainage using a network of ten ground-based tracking stations (Figure 1; Appendices A.2-A.4). Each station consisted of two deep-cycle batteries (12 V), a solar array, an ATS Model 5041 Data Collection Computer (DCC II), an ATS Model 4000 receiver, two Yagi antennas, and a steel housing box. The receiver and DCC II were programmed to scan through the frequencies at 3-s intervals and receive signals from both antennas simultaneously. When a signal of sufficient strength is encountered, the receiver pauses for 12 s on each antenna, and then the tag frequency, tag code, signal strength, date, time, and antenna number are recorded on the data logger. The relatively short cycle period minimizes the chance that a radio-tagged fish will swim past the receiver site without being detected. Receiver data was downloaded to a notebook computer approximately every 7-10 d.

The first tracking station (Baird; rkm 72) was located on the west bank of the Copper River approximately 2 km upstream of Baird Canyon. The second station (Lower Haley; rkm 161) was located on the west bank of the Copper River downstream of the CSDN fishery and the confluence with Haley Creek. The third station (Chitina; rkm 178) was placed on the north bank of the Chitina River approximately 6 km upstream from the confluence mouth of the Chitina River. The fourth station (Copper; rkm 175) was placed on a west-side bluff of the Copper River immediately upstream from the upper boundary of the CSDN fishery. Tagged fish entering the Tonsina, Klutina, Tazlina, and Gulkana rivers were detected at tracking stations placed near the mouths of these rivers. The ninth station (Upper Gulkana; rkm 366) was located at the site of the ADF&G salmon counting tower approximately 2 km upstream from the confluence with the West Fork. The tenth station (Upper Copper; rkm 298) was located on the west bank of the mainstem Copper River approximately 2 km downstream from the mouth of the Gakona River. This station was used to enumerate radio-tagged sockeye salmon entering the Upper Copper River drainage upstream of the Gulkana River.

Aerial-tracking Surveys

The distribution of radio-tagged sockeye salmon was further determined by fixed-wing (Piper Cub) aerial-tracking surveys. The purpose of these surveys was to locate tags in spawning tributaries other than those monitored with tracking stations, to locate fish that the tracking stations failed to record, and to validate that fish recorded on one of the tracking stations did migrate into that particular stream. The aerial surveys were conducted by one person (in addition to the pilot) utilizing one R4500 receiver. All radio-tag frequencies were programmed into the receiver prior to each flight. Dwell time on each frequency was 2 s. Flight altitude ranged from 100-300 m above ground. Two antennas, one on each wing strut, were mounted such that the antennas received peak signals perpendicular to the direction of travel. Once a tag was identified during a flight, the frequency, code, and GPS location were recorded. After the information was recorded the plane circled back to the point where the signal was first heard and tracking resumed.

Fate of Radio-tagged Fish

To facilitate data analysis, all radio-tagged sockeye salmon were assigned a fate based on information obtained from the tracking stations, aerial surveys, and voluntary tag returns from inriver fisheries (Table 1). Telemetry Manager© software developed by LGL Limited (Sidney, BC) was used to organize and analyze the radiotelemetry data.

Spawning Distribution

Radio-tag detections at the tracking stations and during aerial surveys were used to estimate the proportion of fish returning to major spawning tributaries of the Copper River (Lower Copper, Chitina, Tonsina, Klutina, Tazlina, Gulkana and Upper Copper rivers). The Lower Copper included all areas of the mainstem Copper River and its tributaries (e.g., Bremner, Tasnuna, and Tiekel rivers) that were located between the Baird and Lower Haley tracking stations. For the purposes of this study, the Upper Copper area included all waters upstream of the Upper Copper tracking station.

The distribution of sockeye salmon in the seven major spawning areas was estimated as the ratio of radio-tagged fish migrating into a specific tributary to the total number of radio-tagged fish migrating into all spawning tributaries. The proportion of fish that have fate *j* was estimated as:

$$\hat{P}_j = \frac{\sum_{i}^{\text{days}} R_{ij}}{\sum_{j}^{\text{fates}} \sum_{i}^{\text{days}} R_{ij}}, \text{ where:} \tag{1}$$

R_{ij} was the number of fish tagged on day i having fate j. Variance was estimated using bootstrap re-sampling techniques (Efron and Tibshirani 1993). Each bootstrap replicate drew a random sample from the total number of radio tag fates and their corresponding weights. From each replicate the proportion of spawners with spawning fate j ($\hat{P}^*{}_j$) was calculated for a total of 1,000 bootstrap data sets. The percentile method was used to estimate confidence intervals.

In addition to assigning spawners to one of the seven major spawning areas, aerial-tracking data was used to assign fish to specific spawning sites within these drainages. For example, the Upper Copper was subdivided into six specific spawning areas: Copper River mainstem, Gakona River, Chistochina River, Slana River, Suslota Creek/Lake, Mentasta Lake, and Tanada Creek.

Run Timing

Radio-tag detections at the tracking stations were used to estimate stock-specific run-timing patterns. Run-timing patterns were described as time-density functions where the relative abundance of stock j that migrated above the tagging site during time interval t was described by (Mundy 1979):

$$f_j(t) = \frac{R_{tj}}{\sum_{i}^{days} R_{ij}}, \text{ where:} \tag{2}$$

$f_j(t)$ = the empirical temporal probability distribution over the total span of the run for fish spawning in a tributary (or portion thereof) j; and

R_t = the subset of radio-tagged sockeye salmon bound for tributary j that were caught and tagged during day t.

For this purpose, stocks were defined as all sockeye salmon spawning in the Lower Copper, Chitina, Tonsina, Klutina, Tazlina, Gulkana, and the Upper Copper drainages. Those fish assigned a fate of “spawner” were used to determine the time-density functions.

The mean date of passage ($\bar{t}_j$) by the point on the river of tagging for fish spawning in tributary j was estimated as:

$$\bar{t}_j = \sum_t t\, f_j(t), \qquad (3)$$

and the variance of the run timing distribution estimated as:

$$Var\ (t_j) = \sum_t (t - \bar{t}_j)^2 f_j(t). \qquad (4)$$

RESULTS

Capture and Tagging

A total of 521 adult sockeye salmon were radio-tagged at three fishwheels located on the mainstem Copper River at Baird Canyon from 10 May to 3 August 2005 (Figs. 2 and 3; Table 2). Two hundred and twenty fish were radio-tagged at fishwheel 1 on the east bank, 146 fish were tagged at fishwheel 2 on the west bank, and 155 fish were tagged at fishwheel 5 on the west bank. The number of radio tags deployed each day varied from 1 (10 May) to 21 (29 May).

On a regular basis, Miles Lake sonar counts were used to adjust the number of tags deployed at Baird Canyon each day. From 9 May to 31 July 2005, a total of 854,268 fish were counted at the Miles Lake sonar site (Figure 2). Based on these counts, a slightly larger proportion of fish may have been radio-tagged at Baird Canyon in late May than were counted at Miles Lake; whereas in late June, a slightly smaller proportion of fish were radio-tagged than were counted at Miles Lake (Figure 3). These differences were minor and so it was assumed that radio tags were deployed in proportion to the magnitude of the run over the period when Miles Lake sonar counts were reported.

Catch per unit effort (CPUE; fish per hour) for sockeye salmon varied with time and across fishwheels, and thus did not appear to be a reliable index of sockeye salmon abundance (Figure 4). Catch per unit effort varied from 3.3 to 56.6 fish per hour at fishwheel 1, 0.3 to 23.2 fish per hour at fishwheel 2, and 0.2 to 15.1 fish per hour at fishwheel 5. Changes in fishwheel catch efficiency that result from dramatic changes in water levels likely contributed to this variability. For example, there was a 4.1-m change in stage height of the Copper River at Baird Canyon from 16 May to 6 July 2005.
Lengths of radio-tagged sockeye salmon ranged from 430 to 680 mm FL and averaged 566 mm FL (n = 520; Figure 5). Males averaged 584 mm FL (n = 231) and females averaged 551 mm FL (n = 270).

Tracking Stations and Aerial-Tracking Surveys

The Baird tracking station operated from 8 May to 10 July, the Upper Gulkana tracking station operated from 27 June to 2 August, and the remaining eight tracking stations operated from about mid-May to mid-late September (Appendix A.5). Of the 465 radio-tagged fish detected at one or more tracking stations, 365 fish were first detected at the Baird tracking station, 95 fish were first detected at the Lower Haley tracking station, and 5 fish were first detected at the Copper tracking station (Table 3).

Detection efficiencies at the tracking stations ranged from 29% at the Upper Gulkana station to 98% at the Klutina station (Table 3). The Chitina tracking station was not operational from 23-28 June due to damage caused by what was believed to be a bear. The Lower Haley tracking station was not operational from 15-21 July (the memory banks were full) or from 2-18 August (the receiver "froze"). The Tazlina tracking station was not operational from 28 July to 1 August due to a battery failure. In addition, the radio tags used in 2005 did not produce as strong a signal as the radio tags used on Chinook salmon studies conducted in previous years, so the tags were not as easily decoded on receivers at the tracking stations or during aerial-tracking surveys as expected.

Four aerial-tracking surveys of the Copper River drainage were conducted between 7 July and 30 September 2005 and required 13 d to complete (Table 4). The number of radio tags detected during each survey ranged from 108 (21% of tags released) to 218 (42%).

Fate of Radio-Tagged Fish

Spawning Distribution

Of the 521 radio-tagged fish released, 17 fish (3.3%) were never detected after release, 8 fish (1.5%) were last detected downstream of the tagging sites during aerial-tracking surveys, and 496 fish (95.2%) were last detected upstream of the tagging sites (Table 2). Of the 496 radio-tagged fish that migrated upstream of the tagging sites, 299 fish (60.3%) were designated as spawners (which included 12 harvested fish), 54 fish (10.9%) were harvested, and 155 fish (31.3%) were designated as upstream migrants. For the purposes of this report, upstream migrants had an unknown fate and were not used for calculating spawning distribution or run timing estimates.

Of the 299 radio-tagged fish designated as spawners, the largest proportion returned to the Klutina River (0.35%), followed by the Upper Copper (0.28), Tazlina (0.12), Lower Copper (0.07), Gulkana (0.07), Chitina (0.05), and Tonsina (0.05) rivers (Figure 6; Table 5). Specific areas with the most returns included Klutina Lake (25 fish), the Slana River (24 fish), Mentasta Lake (17 fish), the Klutina River upstream of the lake (16 fish), and the Bremner River (16 fish; Table 6). The locations where radio-tagged fish were last detected on aerial-tracking surveys were plotted on maps of each major drainage area (Figs. 7-13).
Twenty radio-tagged fish were reported harvested in the Chitina Subdistrict, 21 fish in the Glennallen Subdistrict, 5 fish in the Klutina sport fishery, and 6 fish in unknown fisheries (i.e., the tags were returned with no information; Appendix A.6). In addition, two radio-tagged fish were presumed harvested in the Chitina Subdistrict based on their detection history.

Run Timing

Run-timing patterns at the capture sites varied among the individual spawning stocks (Figure 14). The mean date of passage at the Baird Canyon fishwheels ranged from 31 May for Tazlina River stocks to 13 July for Tonsina River stocks (Table 7). Lower Copper stocks passed Baird

Canyon from 17 June through 2 August, a period of only 46 d. In contrast, the duration of passage for Gulkana (22 May – 3 August) and Klutina (19 May – 2 August) stocks was considerably more protracted at 73 d and 75 d, respectively.

The upstream migration of radio-tagged sockeye salmon did not appear to be significantly delayed due to capture and handling at the fishwheels. Travel times of radio-tagged fish from release at Baird Canyon to first detection at the Baird tracking station averaged 21 h for fishwheel 1 (n = 177), 19 h for fishwheel 2 (n = 110), and 3 h for fishwheel 5 (n = 77; Figure 15). Fishwheel 5 was located near the Baird tracking station and thus a large proportion of fish were detected immediately following release. Fish released at fishwheels 1 and 2 had to migrate upstream over 1 km before being detected at the Baird station. Eighty-four percent of fish released at fishwheels 1 and 2 were detected at the Baird station within 1 d. One fish released at fishwheel 1 on 26 May was not detected at the Baird station until 15 June, and it was subsequently detected at the Lower Haley, Copper, and Klutina tracking stations and lastly in the lower Klutina River during an aerial-tracking survey on 9 July.

Travel times for radio-tagged sockeye salmon to migrate between the Baird and Lower Haley tracking stations ranged from 3.4 to 44.6 d and the median was 8.4 d (Table 8). Over this 89-km distance, these travel times corresponded to migration speeds ranging from 2 km/d to 26 km/d. Median travel times from the Baird tracking station to harvest in the Chitina Subdistrict, Glennallen Subdistrict, and Klutina sport fisheries were 11, 21, and 23 d, respectively (Table 8).

DISCUSSION

Capture and Tagging

In 2005, the Baird Canyon fishwheels began operating earlier than in previous years due to relatively light snow loads and early break up of river ice. Fishwheel 2 began fishing on 9 May, the first sockeye salmon was radio-tagged on 10 May, and fishing effort at Baird Canyon was continuous until 3 August. In years past, fishing effort at Baird Canyon has been interrupted or discontinued due to high water levels. In 2005, a small fishwheel (fishwheel 5) was used at Baird Canyon which was able to operate during periods of high water when the two large fishwheels were less effective.

Two assumptions must be met in order to obtain unbiased estimates of the spawning distribution: (1) handling and radio-tagging sockeye salmon did not affect their natural behavior (i.e., final spawning destination); and (2) captured sockeye salmon were radio-tagged in proportion to the magnitude and timing of the run. There was no explicit test for the first assumption because the behavior of unhandled fish could not be observed. However, several observations indicated that sockeye salmon radio-tagged in 2005 were not adversely affected by the capture, handling, or tagging process. Of the 521 radio-tagged fish released, 95.2% were last detected upstream of the tagging site and only 1.5% were last detected downstream of the tagging site (the remaining 3.3% were never detected after release; Table 2). The tags last detected downstream of the tagging site may have been regurgitated or they were in fish that died after release. Additionally, the majority of radio-tagged fish migrated upstream of the tagging site within a day of being released (Figure 15). These findings compare favorably to other sockeye salmon radiotelemetry studies conducted in Alaska. Waltemyer et al. (2005) reported that 16% of sockeye salmon radio-tagged on the East Alsek River in 2004 were last detected in the vicinity of the tagging site, and 4% of the fish were never detected after release. During a 2002 study in the Chignik Lake system, 89% of radio-tagged sockeye salmon resumed their upstream migration after release (Anderson 2003). During a three-year study (1999-2001) on Lake Clark, Ramstad and Woody (2003) found no significant tag loss or increase in mortality rates associated with radio-tagged sockeye salmon.

Salmon counts at the Miles Lake sonar site provided the only independent inseason index of salmon abundance that could be used to evaluate whether our tags were deployed in proportion to the magnitude and timing of the run (assumption 2). Miles Lake sonar counts were low on 9 May (192 fish) and 10 May (451 fish), as were sockeye salmon catches at fishwheel 2 from 10-12 May (2-8 fish), indicating that radio-tagging began close to the onset of the run (Figure 2). In contrast, evidence suggests that radio-tagging may have stopped prior to the end of the run. The last sockeye salmon was radio-tagged on 3 August. Only three days earlier (on 31 July), the Miles Lake sonar counted 5,884 salmon. As part of a separate steelhead and coho salmon study, ADF&G operated a fishwheel from 15 August to 6 October near Canyon Creek, approximately 89 rkm upstream of Baird Canyon. During this period, over 4,000 sockeye salmon were captured. Based on this information, a small proportion of the run may have migrated through Baird Canyon after 3 August with no chance of being radio-tagged. As a result, the spawning distribution and run timing estimates for these late-run stocks may be biased by an unknown but likely small amount. It is recommended that the fishwheels continue operating through at least mid-August 2006 so that radio tags can be deployed across the entire sockeye salmon run.

Previous radiotelemetry studies on Chinook salmon have shown that stock-specific differences in run timing can lead to biased estimates of spawning distribution because the probability of capturing fish often varies over time (Savereide 2004). This bias can be corrected by adjusting the distribution estimates based on estimated total passage. Using passage rather than CPUE is preferred, because CPUE may not vary in proportion to passage due to fluctuations in gear efficiency that result from changes in river water levels and fishwheel placement. In this study, no information on total passage was available; therefore it was not possible to detect or describe any bias in the estimate of spawning distribution. It was assumed that the magnitude of this bias was small relative to the estimate. In 2006, a concurrent mark-recapture study on sockeye salmon will provide the information required to correct for any bias due to stock-specific run timing and catchability.

Fate of Radio-tagged Fish

In 2005, the proportion of radio-tagged sockeye salmon designated as upstream migrants (30% of 521 released), or fish that moved upstream of the tagging sites but were never detected in known spawning areas, was higher than anticipated. If the final spawning destination of a radio-tagged fish can not be determined, then that fish can not be used to generate the spawning distribution and run timing estimates. Ultimately, smaller sample sizes may reduce the accuracy and/or precision of the parameter estimates. Several factors may have contributed to the relatively high number of fish being designated as upstream migrants.

Twenty-eight fish were last detected at or above the Baird tracking station and downstream of the Lower Haley tracking station. It is possible that some of these fish were in fact spawners. In addition to the Bremner and Tasnuna rivers (Thompson 1964), there are several known spawning areas located near the mainstem Copper River in this region. These include spawning areas near the mouth of the Tasnuna River, in the Peninsula Lakes on the east bank of the Copper River just upstream of the Bremner River, at the mouth of the Tiekel River, in the Swan lakes across from Cirque Creek, and the mouth of the Uranatina River. Unfortunately, detections from aerial-tracking surveys in 2005 could not provide enough resolution (spatially or temporally) to clearly identify fish that were last detected in this region as spawners. In 2006, it is recommended that regular mobile-tracking surveys in a boat be conducted between the Chitina-McCarthy Bridge and Miles Lake to help identify the specific location and ultimate fate of radio-tagged fish.

In addition, 92 fish were last detected at or between the Lower Haley (rkm 161) and Copper (rkm 175) tracking stations. This section of the Copper River is found almost entirely within the boundaries of the Chitina Subdistrict dip net fishery and it contains no known sockeye salmon spawning areas of significance. Based on this information, a substantial number of the radio-tagged fish last detected in this area were likely harvested. Radio-tagged fish did not receive a secondary mark (e.g., a brightly colored spaghetti tag), so it is conceivable that radio-tagged fish were caught but the tag itself was not detected. In 2006, it is recommended that a secondary mark be applied to all radio-tagged fish and a tracking station be added near the mouth of O'Brien Creek to improve the tracking coverage of fish harvested in the dip net fishery. Increased public awareness of the study should also be considered as a method to increase the proportion of harvested tags that are reported.

As mentioned earlier, past studies to assess the distribution and run timing of Copper River sockeye salmon have been limited are now somewhat outdated. Based on data collected from 1967 to 1972, Merritt and Roberson (1986) reported that the two stocks with the greatest estimated spawning population size were in the Gulkana (Upper Gulkana) and Chitina (Long Lake) rivers. In 2005, the largest proportion of spawners returned to the Klutina (0.35), Upper Copper (0.28), and Tazlina (0.12) drainages (Figure 6; Table 5). Significant spawning areas included the mainstem Klutina River, Slana River, and Mentasta Lake (Figure 7).

It is interesting to note that 7.4% of spawners returned to tributaries in the Lower Copper drainage. For reasons described earlier, this proportion may have been biased low. Fish returning to the Lower Copper drainage are counted at the Miles Lake sonar site but are unavailable to the inriver fisheries. This Lower Copper component of the run may account for at least some of the fish that are believed to go "missing" between the Miles Lake sonar site and the inriver fisheries and upper river spawning escapement.

Merritt and Roberson (1986) also found that groups of stocks with early mean arrival dates tended to spawn in the uppermost areas of the Copper River drainage. Results from the 2005 study showed a similar trend (Figure 7). The mean date of passage at Baird Canyon for the Klutina, Tazlina, and Upper Copper stocks was earlier than the mean date of passage for Lower

Copper, Chitina, and Tonsina stocks (Table 7). An exception to this trend was the Gulkana River stocks. Although the Gulkana River is located higher in the drainage than the Klutina and Tazlina rivers, Gulkana River fish displayed a later run timing pattern (mean date of passage was 4 July). This may be due to the fact that the majority of the Gulkana River run consists of hatchery fish.

CONCLUSIONS

This year (2005) was the first of a three-year study to estimate the spawning distribution and run timing of Copper River sockeye salmon. Despite numerous challenges encountered during the 2005 field season, all project objectives were met or exceeded. Fishery technicians hired by NVE acquired the skills and experience required for this and other fisheries research jobs. The addition of this project has helped NVE to become an integral part of Copper River salmon research and management. This project promoted interaction between a major subsistence group (NVE) and various management agencies (USFWS, ADF&G Division of Sport Fish, ADF&G Division of Commercial Fisheries). This project also engaged tribal organizations from different regions and promoted interactions amongst subsistence users.

RECOMMENDATIONS FOR 2006

The following are recommended for the 2006 field season:

1) Radio-tag sockeye salmon through August to ensure late-run fish are represented;
2) Use radio tags that emit a stronger signal than the ones used in 2005 to ensure that they are more easily detected at tracking stations and during aerial-tracking surveys;
3) Install and operate a tracking station at O'Brien Creek to help identify whether or not radio-tagged fish were harvested in the Chitina Subdistrict;
4) Test all radio tags on the day they are deployed to ensure they are functioning properly;
5) Conduct inseason mobile-tracking surveys by boat between Chitina and Miles Lake to obtain more detailed tracking data and identify potential spawners which would otherwise be classified as upstream migrants;
6) Utilize a brightly colored spaghetti tag as a secondary mark on radio-tagged fish which will allow easier identification by harvesters and technicians at the Gulkana Hatchery, and ultimately improve information on the known fate of harvested fish; and
7) Increase public awareness of the study in an effort to increase the proportion of tags reported (and returned for re-deployment) from inriver fisheries.

ACKNOWLEDGMENTS

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LITERATURE CITED

AAC. 2004. 5 AAC 24.360. Alaska Fish and Game Laws and Regulations Annotated 2003-2004 Edition. Ed. Lexis Publishing, New York.

ADF&G. 2006. Commercial fisheries news release, 2005 season summary. Retrieved on 13 March 2006 from the Alaska Department of Fish and Game, Division of Commercial Fisheries webpage: http://www.cf.adfg.state.ak.us/region2/pwshome.php.

Anderson, J. L. 2003. Estimation of late run sockeye and coho salmon escapement in the Clark River, a tributary to Chignik Lake, Alaska Peninsula National Wildlife Refuge, 2002. U.S. Fish and Wildlife Service, King Salmon Fish and Wildlife Field Office, Alaska Fisheries Technical Report No. 64, King Salmon.

Ashe, D., D. Gray, B. Lewis, S. Moffitt, and R. Merizon. 2005. Prince William Sound management area 2004 annual finfish management report. Alaska Department of Fish and Game, Fishery Management Report No. 05-65, Anchorage.

Ashe, D., and T. Taube. 2002. Management of salmon stocks in the Copper River: report to the Alaska Board of Fisheries. Alaska Department of Fish and Game, Regional Information Report No. 2A02-36, Anchorage.

Brabets, T. P. 1997. Geomorphology of the lower Copper River, Alaska. United States Geological Survey, U.S. Geological Survey Professional Paper 1581, Denver.

Buklis, L. S. 2002. Subsistence fisheries management on Federal public lands in Alaska. Fisheries 27(7): 10-18.

Degan, D., A. M. Mueller, J. J. Smith, S. Moffitt, and N. Gove. 2004. Assessing methods to index inseason salmon abundance in the lower Copper River, 2003 Annual Report. US Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-021), Anchorage, Alaska.

Efron, B., and R. J. Tibshirani. 1993. An introduction to the bootstrap. Chapman and Hall, New York.

Hollowell, G., and T. Taube. 2005. Management of salmon stocks in the Copper River: report to the Alaska Board of Fisheries, Valdez, Alaska. Alaska Department of Fish and Game, Cordova, Alaska.

Lambert, M. B., D. Degan, A. M. Mueller, S. Moffitt, B. Marston, N. Gove, and J. J. Smith. 2003. Assessing methods to index inseason salmon abundance in the lower Copper River, 2002 Annual Report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-021), Anchorage, Alaska.

Link, M. R., B. Haley, D. Degan, A. M. Mueller, S. Moffitt, N. Gove, and R. Henrichs. 2001a. Assessing methods to estimate inseason salmon abundance in the lower Copper River. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-021), Anchorage, Alaska.

Link, M. R., M. J. Nemeth, and R. Henrichs. 2001b. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River. U.S. Fish and Wildlife Service, Office of Subsistence Management, Anchorage.

Merritt, M. F., and K. Roberson. 1986. Migratory timing of upper Copper River sockeye salmon stocks and its implications for the regulation of the commercial fishery. N. Amer. J. Fish. Manag. 6: 216-225.

Mueller, A. M., and D. Degan. 2005. Indexing the inseason abundance of salmon in the lower reaches of the Copper River Delta, 2004 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 04-506), Anchorage, Alaska.

Mundy, P. R. 1979. A quantitative measure of migratory timing illustrated by application to the management of commercial fisheries. Phd. Dissertation. University of Washington.

National Park Service (NPS). 2005. Tanada Creek fish weir project. Retrieved on 6 December 2005 from the National Park Service, Wrangell-St. Elias National Park and Preserve webpage: http://www.nps.gov/wrst/subsistence/tanadaweir200.htm.

Ramstad, K. M., and C. A. Woody. 2003. Radio tag retention and tag-related mortality among adult sockeye salmon. N. Amer. J. Fish. Manag. 23(3): 978-982.

Roberson, K. 1987. Copper River subsistence and personal use salmon fishery management and research - 1987. Alaska Department of Fish and Game, Division of Commercial Fisheries, Prince William Sound Data Report #1987-9 (a report to the Board of Fisheries), Glennallen, Alaska.

Savereide, J. W. 2004. Inriver abundance, spawning distribution, and run timing of Copper River Chinook salmon in 2003. Alaska Department of Fish and Game, Fishery Data Series No. 04-26, Anchorage.

Smith, J. J. 2004. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River, 2003 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-020), Anchorage, Alaska.

Smith, J. J., M. R. Link, and M. B. Lambert. 2003. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River, 2002 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 01-020), Anchorage, Alaska.

Smith, J. J., and K. van den Broek. 2005. Feasibility of using fishwheels for long-term monitoring of Chinook salmon escapement on the Copper River, 2004 annual report. U.S. Fish and Wildlife Service, Office of Subsistence Management, Fisheries Resource Monitoring Program (Study No. 04-503), Anchorage, Alaska.

Taube, T. 2002. Area management report for the recreational fisheries of the Upper Copper/Upper Susitna River management area, 2000-2001. Alaska Department of Fish and Game, Fishery Management Series No. 02-07, Anchorage.

Thompson, S. H. 1964. The red salmon (Oncorhynchus nerka) of Copper River, Alaska. Department of the Interior, U.S. Fish and Wildlife Service, Bureau of Commercial Fisheries, Biological Laboratory, Manuscript Report 64-12, Auke Bay, AK.

Waltemyer, D. L., D. Reed, M. Tracy, and J. H. Clark. 2005. A mark-recapture experiment to estimate the escapement of sockeye salmon in the East Alsek River, 2004. Alaska Department of Fish and Game, Fishery Data Series No 05-27, Anchorage.

FIGURES

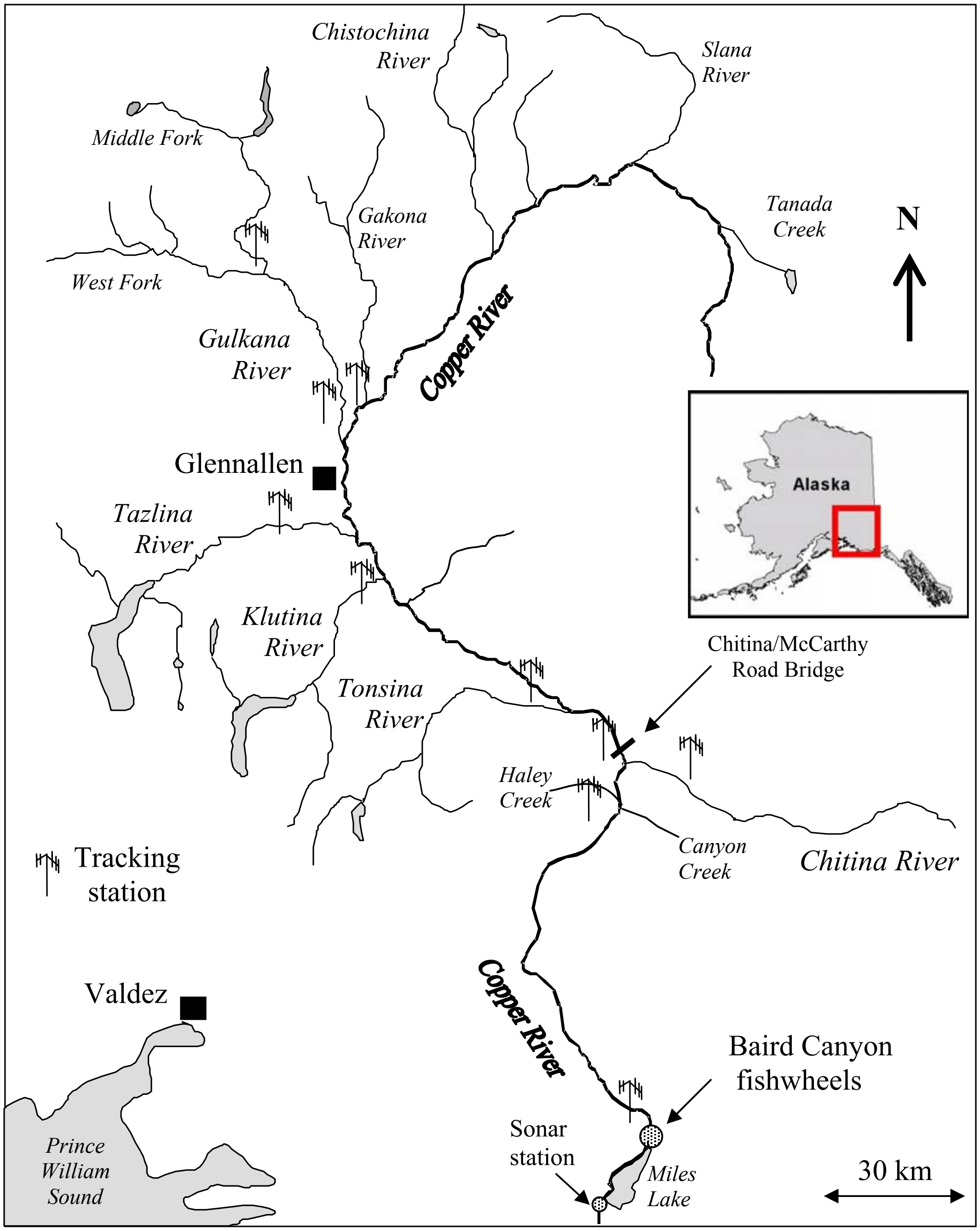


Figure 1. Map of the Copper River watershed in Southcentral Alaska showing the location of the fishwheels used to capture sockeye salmon and ten fixed stations used for tracking radio-tagged fish, 2005.

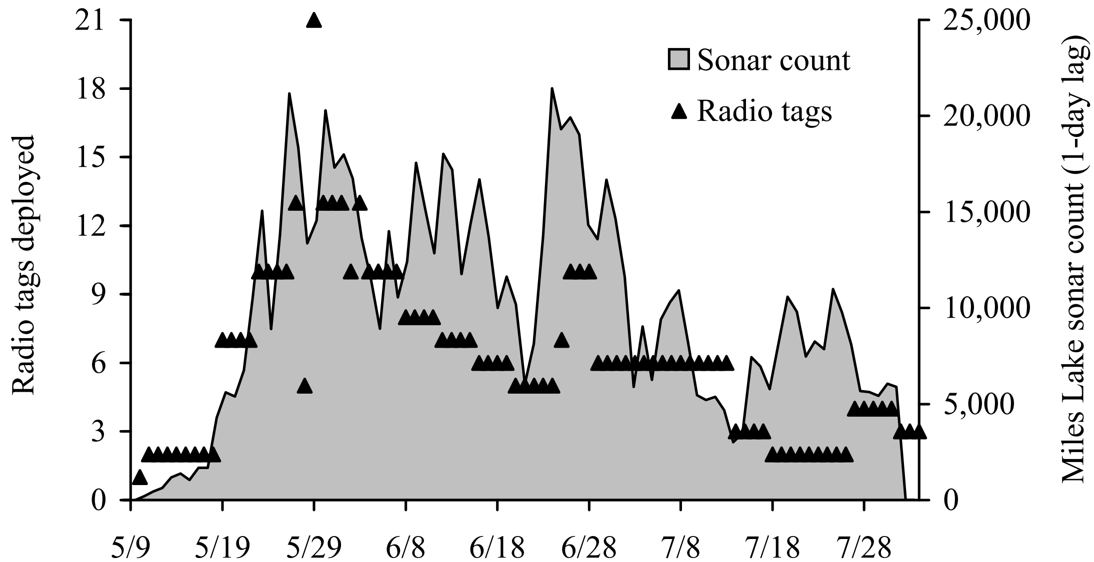


Figure 2. Daily number of sockeye salmon radio-tagged at the Baird Canyon fishwheels and the daily number of salmon counted at the Miles Lake sonar, 2005.

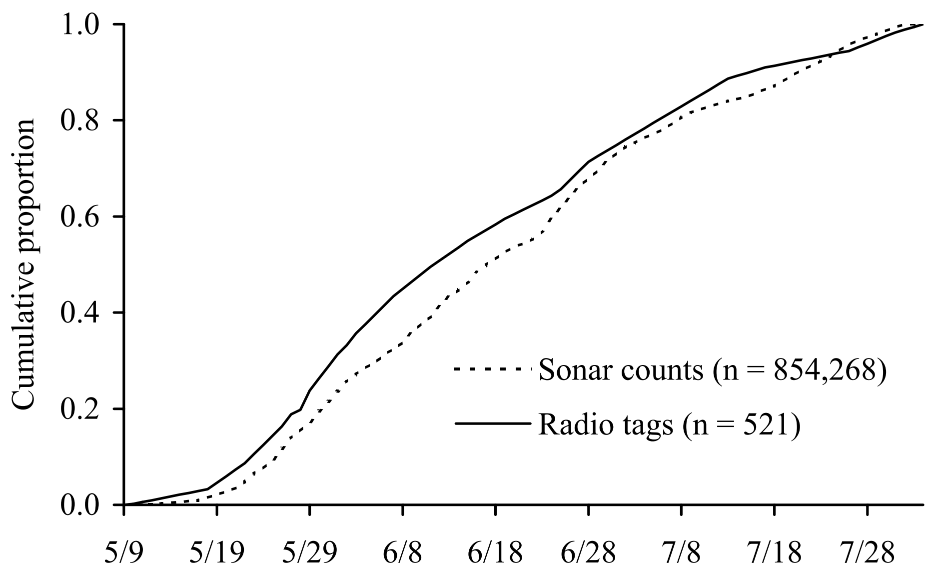


Figure 3. Cumulative number of sockeye salmon radio-tagged at the Baird Canyon fishwheels and the cumulative number of salmon counted at the Miles Lake sonar, 2005.

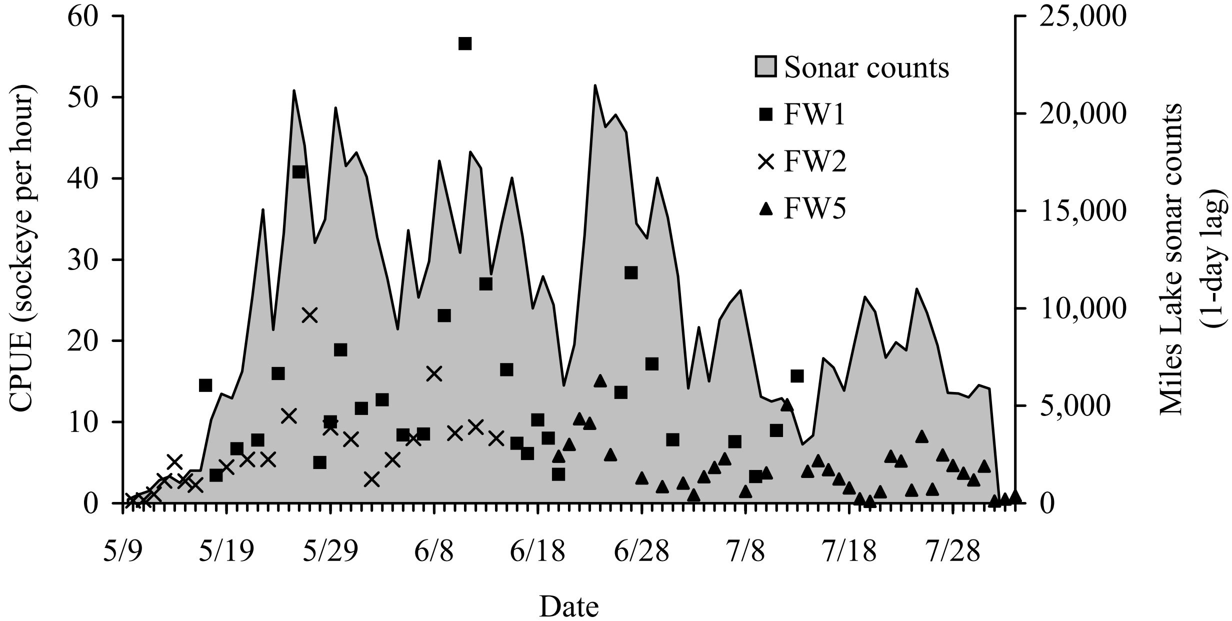


Figure 4. Catch per unit effort (fish per hour) for sockeye salmon captured at the Baird Canyon fishwheels during periods when the escape panels were closed, 2005. Daily counts at the Miles Lake sonar site in 2005 are shown for comparison.

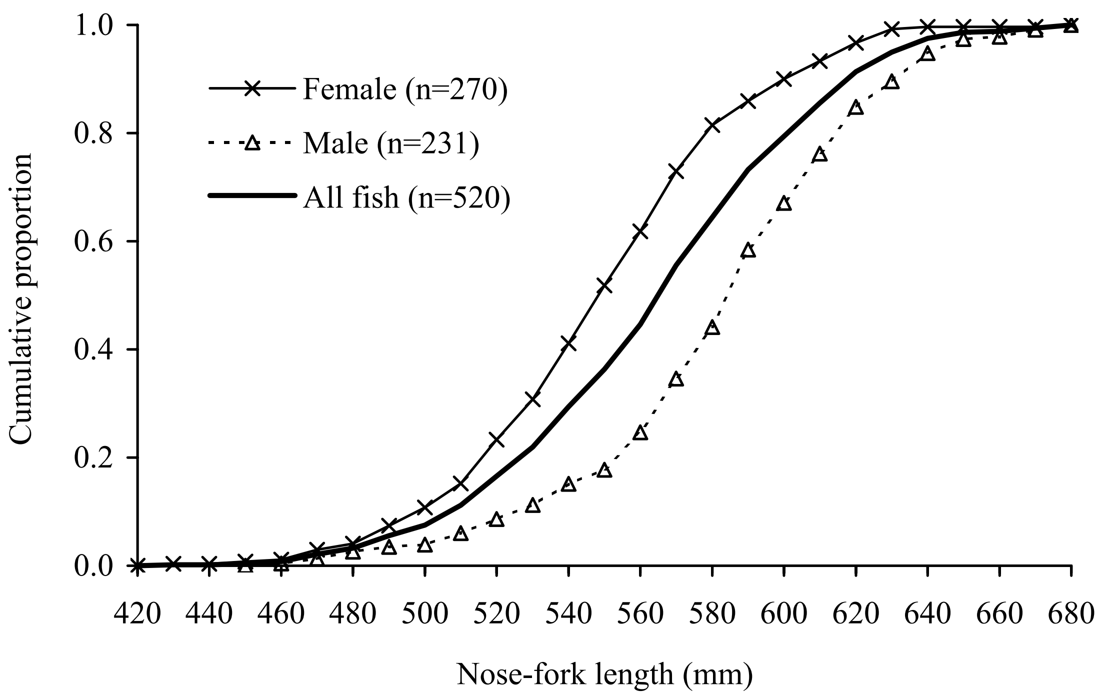


Figure 5. Cumulative length-frequency distributions for sockeye salmon radio-tagged at the Baird Canyon fishwheels on the Copper River, 2005.

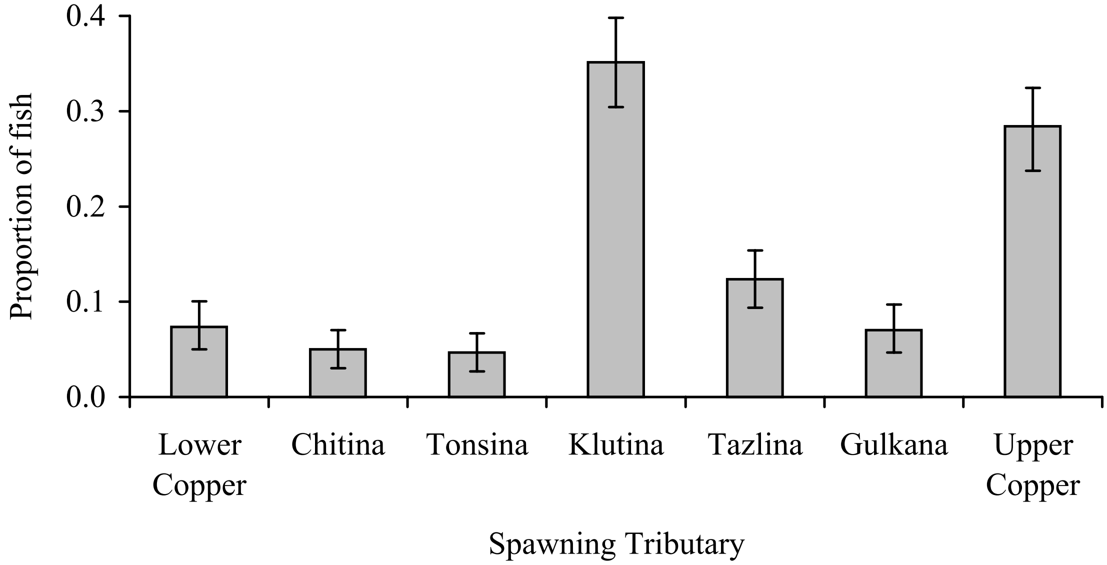


Figure 6. Spawning distribution and 95% confidence intervals of Copper River sockeye salmon by major drainage, 2005.

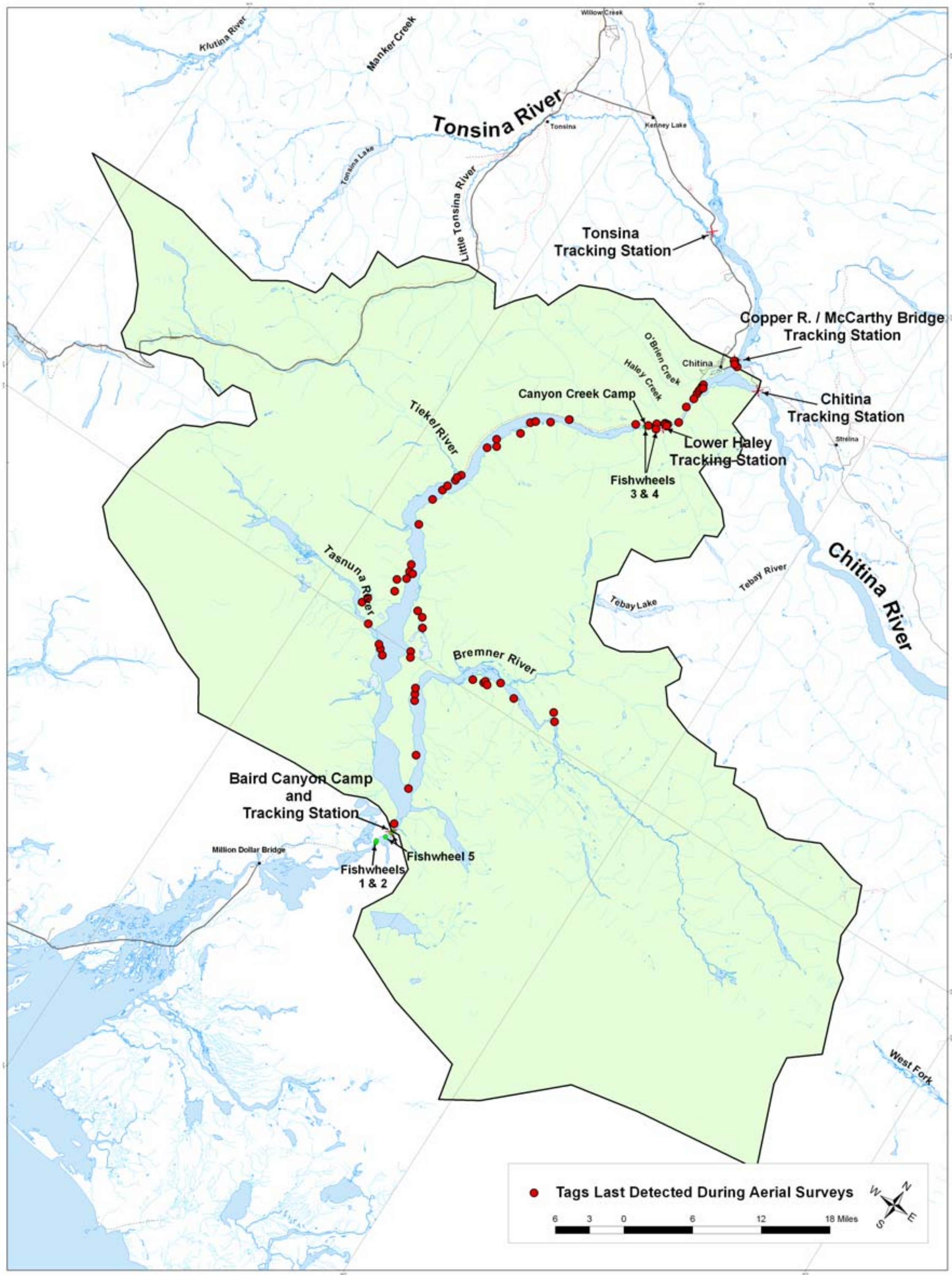


Figure 7. Map of the Lower Copper River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

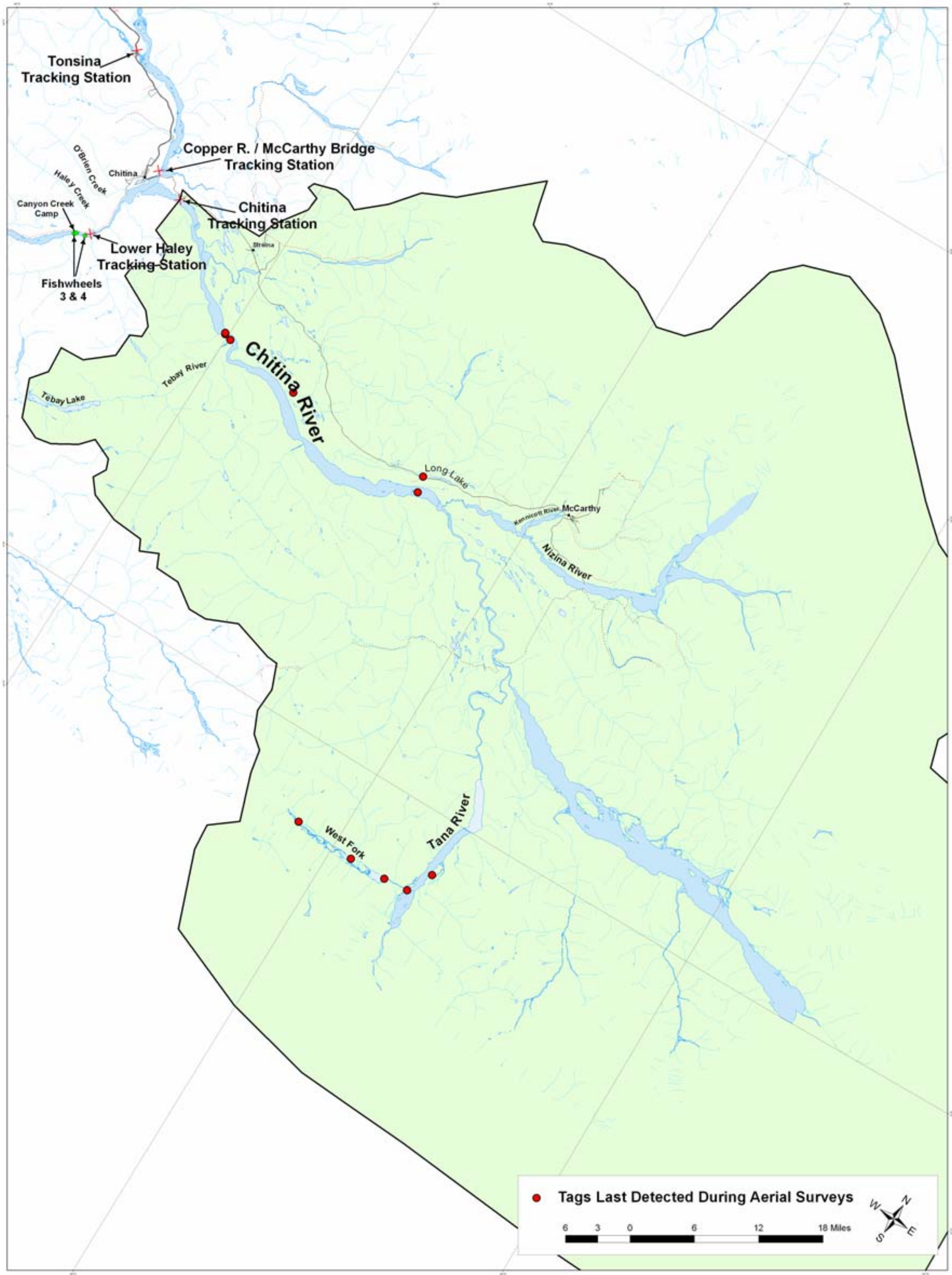


Figure 8. Map of the Chitina River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

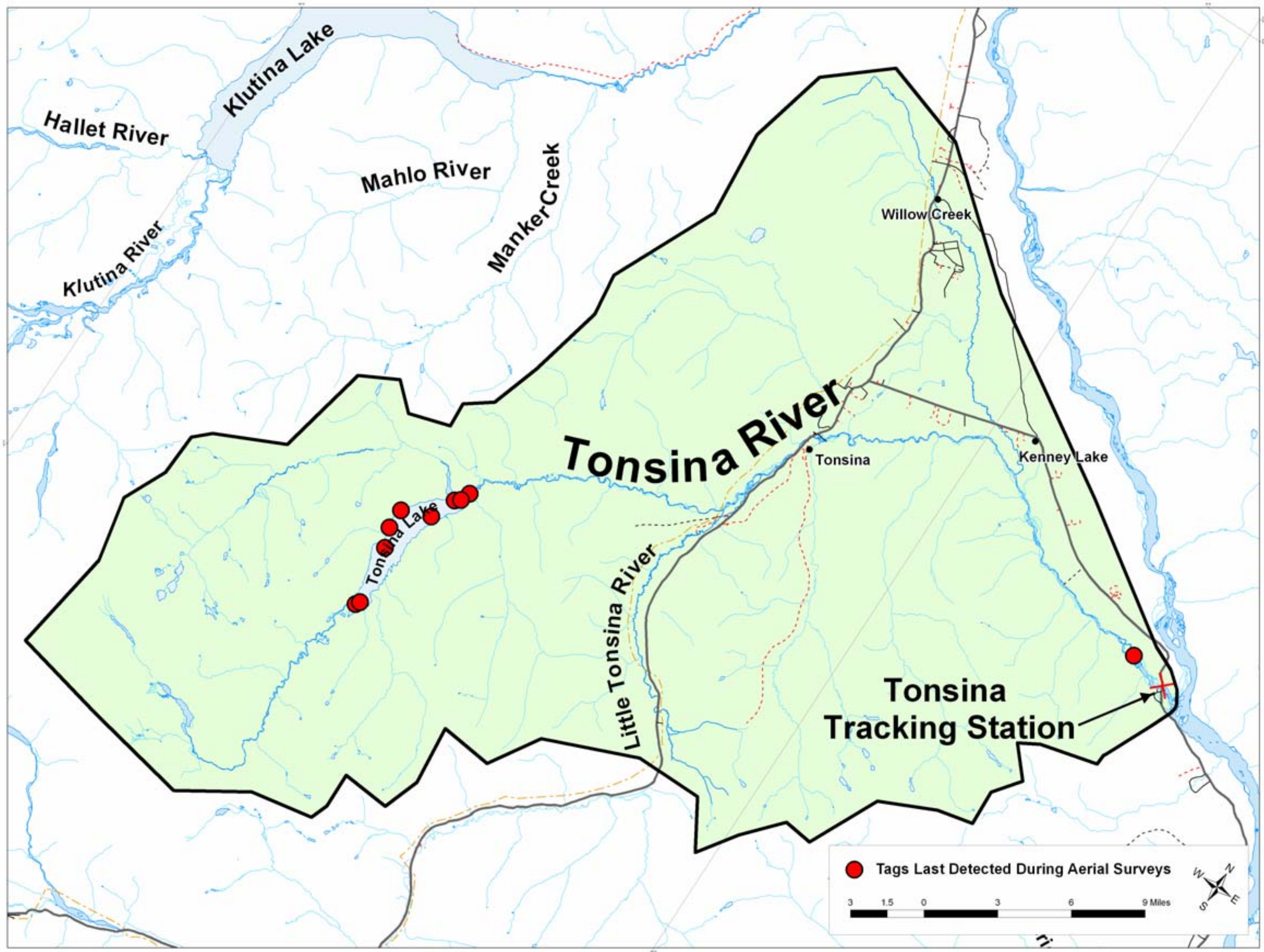


Figure 9. Map of the Tonsina River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

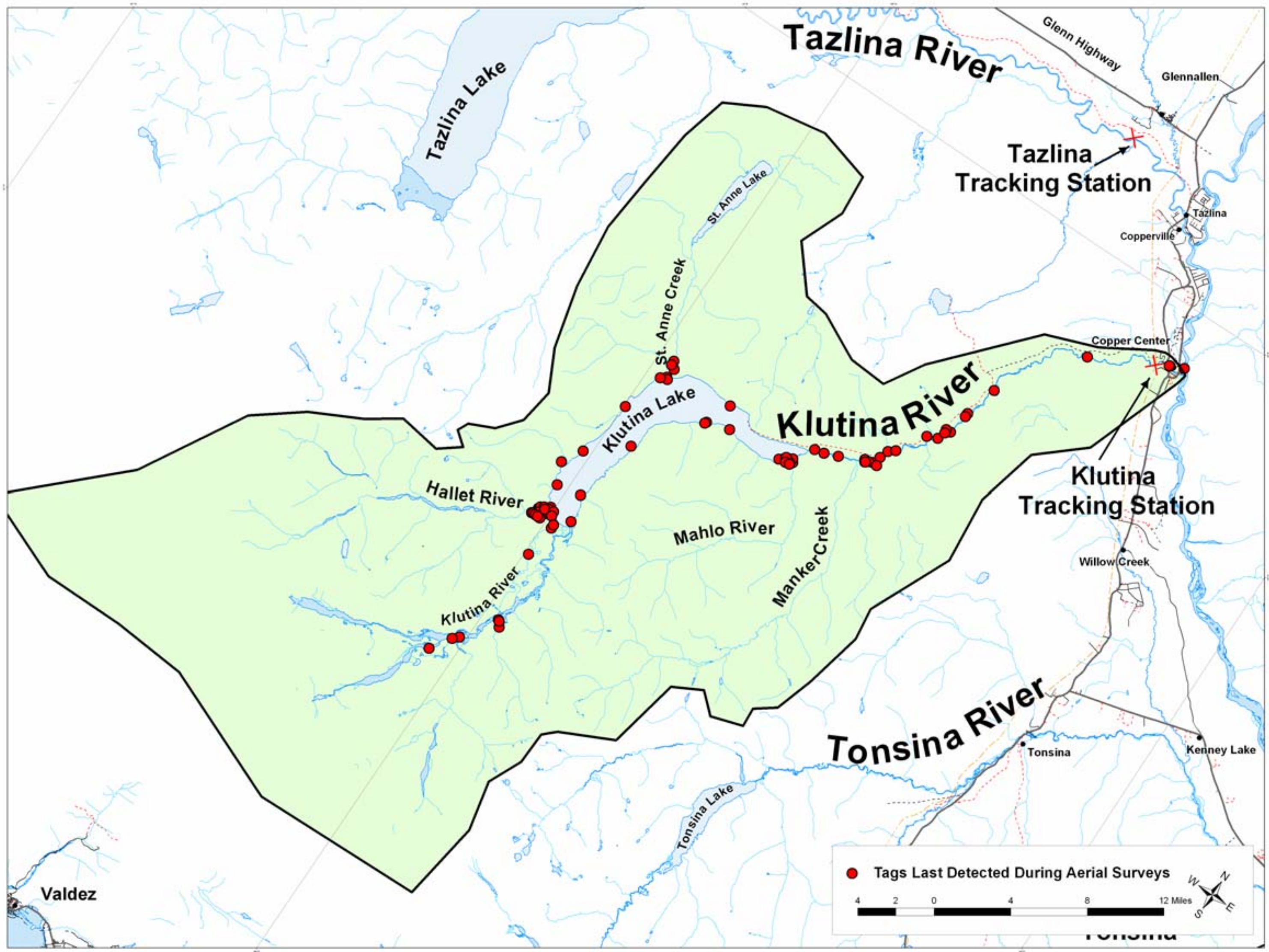


Figure 10. Map of the Klutina River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

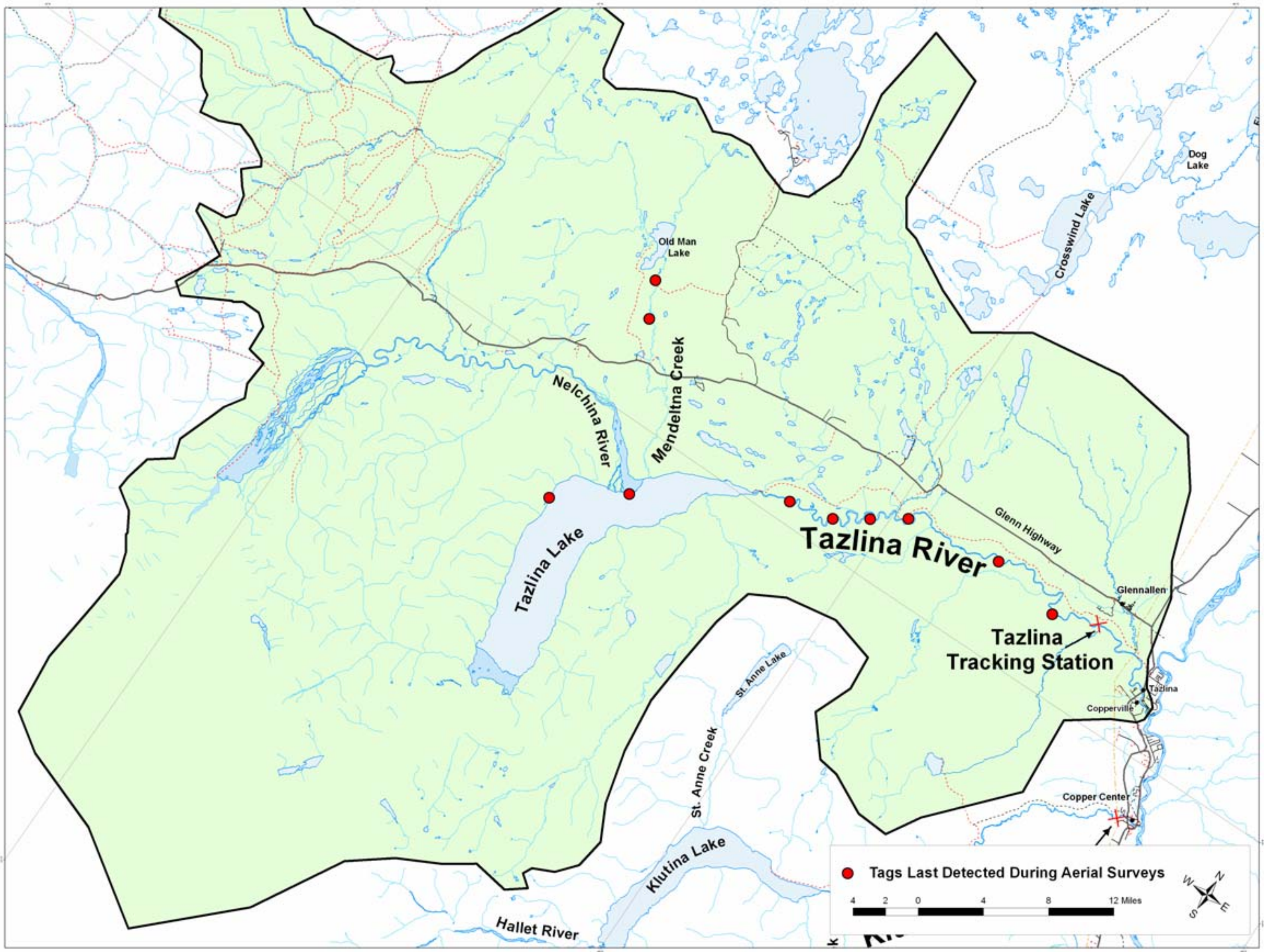


Figure 11. Map of the Tazlina River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

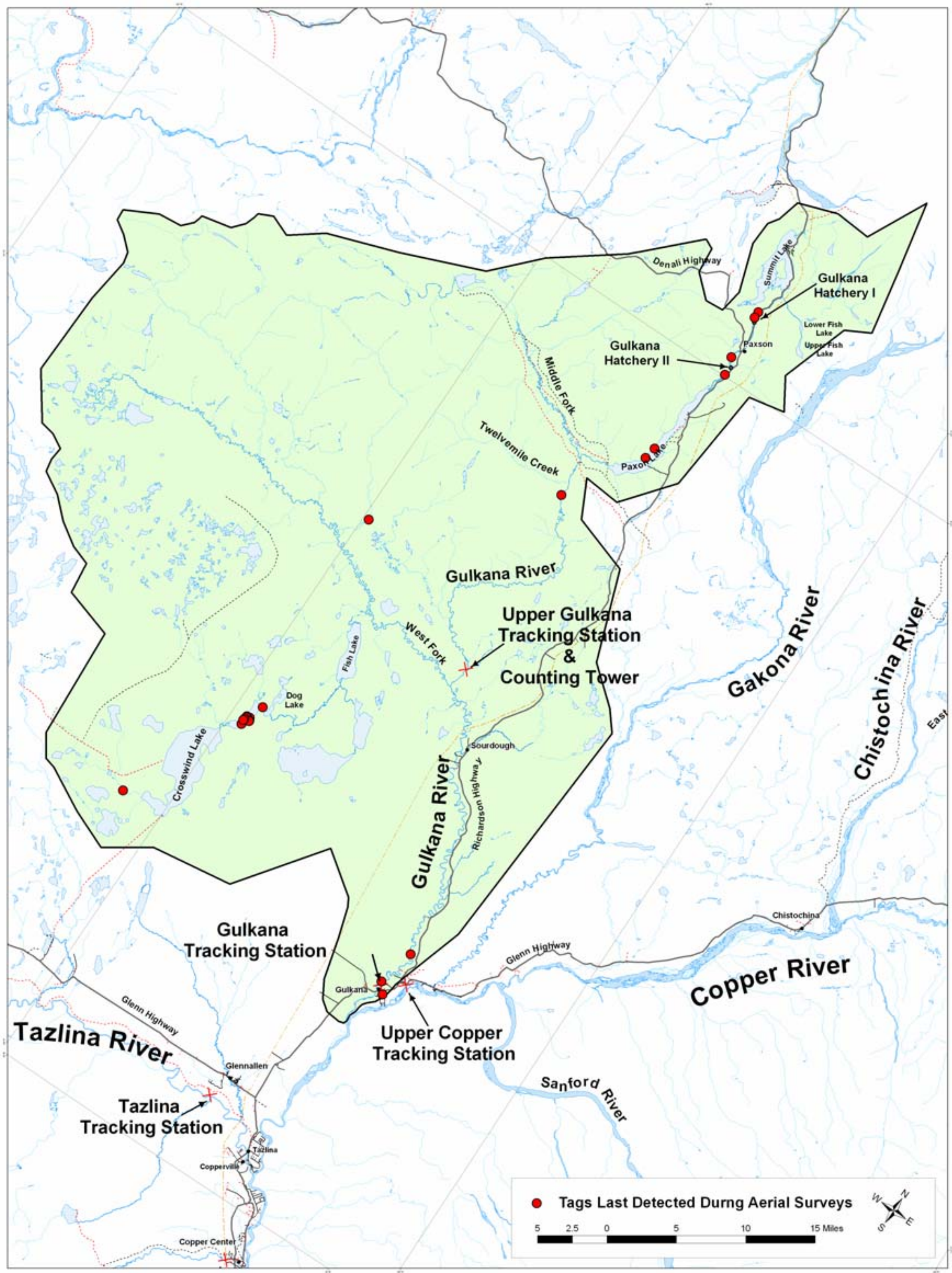


Figure 12. Map of the Gulkana River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

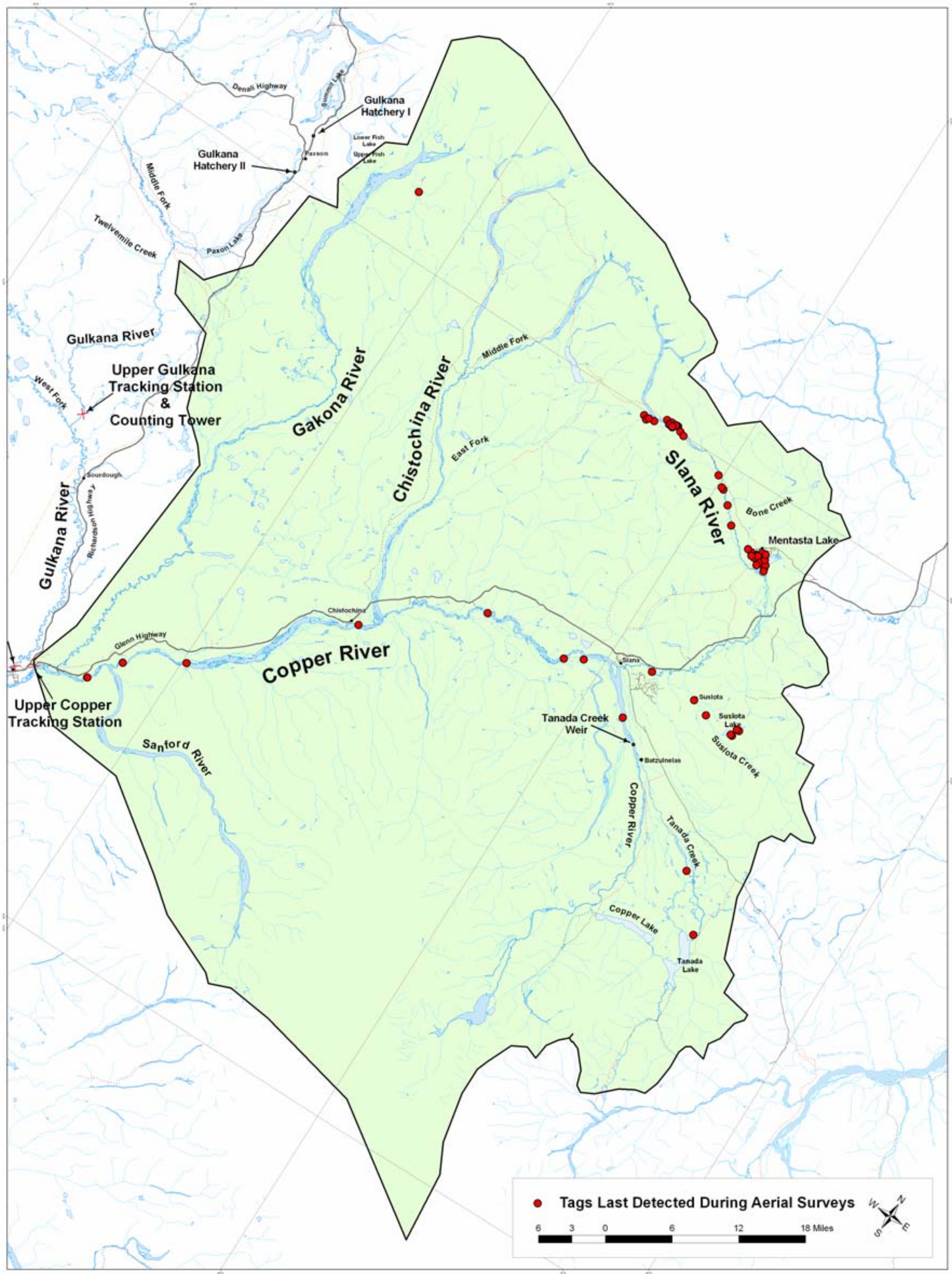


Figure 13. Map of the Upper Copper River drainage showing the location where radio-tagged sockeye salmon were last detected on aerial-tracking surveys, 2005.

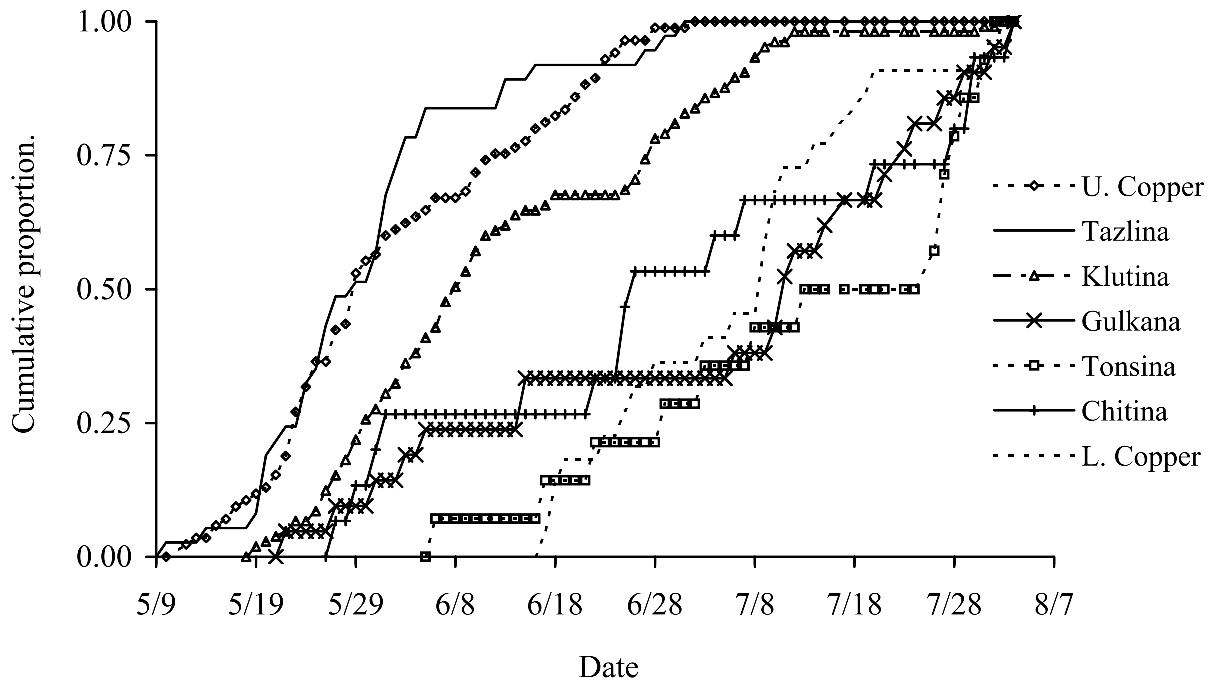


Figure 14. Run-timing patterns of sockeye salmon at the capture site for the major stocks in the Copper River, 2005.

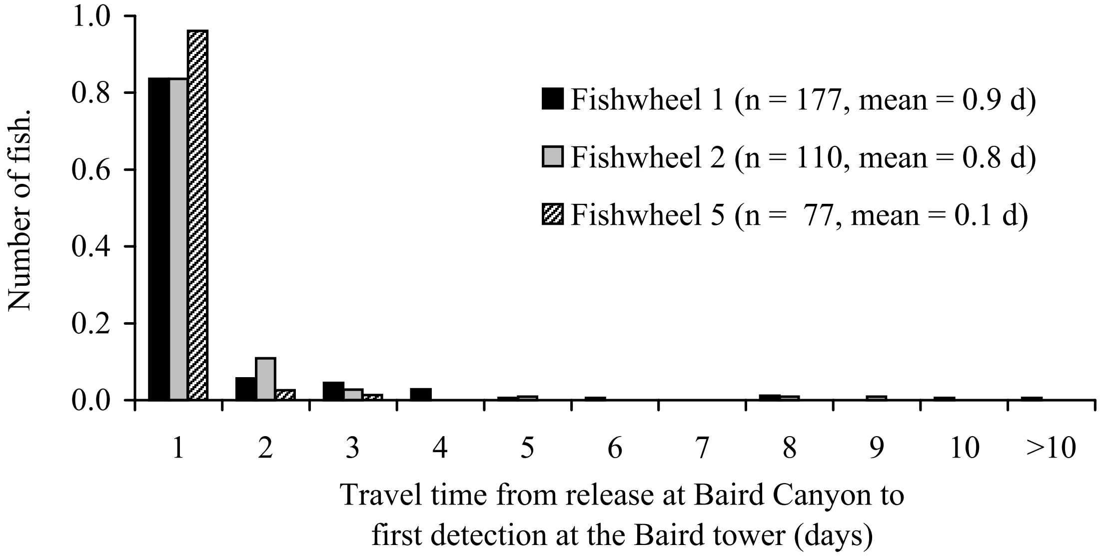


Figure 15. Travel time (days) for radio-tagged sockeye salmon from release at the Baird Canyon fishwheels to first detection at the Baird tower, 2005.

TABLES

Table 1. List of possible fates for radio-tagged sockeye salmon on the Copper River, 2005.

Fate	Description
Radio Failure	Never recorded swimming upstream of the Baird tracking station.
Chitina Subdistrict Fishery Mortality	Harvested in the Chitina Subdistrict.
Glennallen Subdistrict Fishery Mortality	Harvested in the Glennallen Subdistrict.
Sport Fishery Mortality	Harvested in one of the sport fisheries.
Unknown Fishery Mortality	Harvested, but the specific location of harvest was unknown.
Spawner [a]	Entered a spawning tributary of the Copper River or was detected on two or more aerial-tracking surveys in the vicinity of a known spawning area close to the mainstem in the lower Copper River (e.g., Tiekel River or Swan Lakes).
Upstream migrant	Migrated upstream of the Baird station, but was never reported as harvested, and was either never detected after passing the Baird station, or was only detected in the mainstem Copper River between the Baird and Upper Copper stations but not near a known spawning area.

[a] These radio-tagged fish were used to estimate spawning distribution and stock-specific run timing.

Table 2. Fates of sockeye salmon that were radio-tagged at the Baird Canyon fishwheels on the Copper River, 2005.

Fate [a]	Fishwheel 1	Fishwheel 2	Fishwheel 5	Total
Deployed at Baird Canyon	220	146	155	521
Radio Failure [b]	11	4	10	25
Chitina Subdistrict	8	7	7	22
Glennallen Subdistrict	6	10	5	21
Sport fishery	3	2	0	5
Unknown fishery	1	4	1	6
Upstream migrant [c]	65	38	52	155
Spawner [d]	134	84	81	299

[a] Refer to Table 1 for a description of fates.

[b] Includes 17 radio tags never detected after release and 8 radio tags that were last detected downstream of the tagging site.

[c] Migrated upstream of the Baird station, but was never reported as harvested, and was either never detected after passing the Baird station, or was only detected in the mainstem Copper River between the Baird and Upper Copper stations but not near a known spawning area.

[d] Includes 5 fish harvested in the Klutina sport fishery (3 @ FW1, 2 @ FW2) and 7 fish harvested in the Glennallen Subdistrict upstream of the Upper Copper tracking station (4 @ FW1, 1 @ FW2, 1 @ FW5).

Table 3. Number of radio-tagged sockeye salmon detected at the tracking stations in the Copper River basin, 2005.

		Number of fish			Detection
		First	Total	Total	Efficiency
Zone #	Location	Detection	Detected	Passed	(%)
-1	Baird fishwheels		521		
10	Baird	365	365	496	73.6
20	Lower Haley	95	424	451	94.0
30	Chitina		35	36	97.2
40	Copper	5	275	387	71.1
60	Tonsina		23	24	95.8
70	Klutina		107	109	98.2
80	Tazlina		34	38	89.5
90	Gulkana		26	27	96.3
100	Upper Gulkana		5	17	29.4
110	Upper Copper		77	135	57.0
Total		465			

Table 4. Number of radio-tagged fish detected, by area and date, during aerial surveys in the Copper River drainage, 2005.

Zone	Survey Location	7-Jul	9-Jul	2-Aug	6-Aug	7-Aug	8-Aug	31-Aug	1-Sep	2-Sep	3-Sep	19-Sep	28-Sep	30-Sep	Total
5	Copper mainstem - mouth to Baird										8				8
6	Bremner River			8							15				23
7	Tasnuna River			3							3				6
15	Copper mainstem - Baird to Lower Haley			28							20				48
25	Copper mainstem - Lower Haley to Copper		1	17							5	3			26
351	Chitina River mainstem			2							4				6
352	Lakina River/Long Lake			0							1				1
353	Tana River			3							5				8
55	Copper mainstem - Copper to Upper Copper		45	4	15		2	20		1	7	23			117
65	Tonsina River		0		2			7						9	18
751	Lower Klutina mainstem		14		14			10						17	55
752	Klutina Lake		4		24			11						11	50
753	Mahlo Creek		2		12			7						8	29
754	St. Anne Creek		3		4			2						3	12
755	Upper Klutina mainstem		0		14			15						10	39
851	Mendeltna Creek		3		4			6						6	19
852	Tazlina mainstem/Lake		0		1			2						2	5
951	Lower Gulkana	0				0			10			2			12
952	Upper Gulkana	1				3			1	3		7			15
97	West Fork Gulkana River	1				0			2			11			14
115	Copper mainstem - u/s Upper Copper station	6					12			8			6		32
116	Gakona River	1					0			1		1	0		3
1181	Slana River	20					23			22			18		83
1182	Suslota Creek/Lake	0					4			6			5		15
1183	Mentasta Lake	7					9			15			15		46
119	Tanada Creek						0			1			2		3
Total		36	72	65	90	3	50	80	13	57	68	47	46	66	693

Table 5. Distribution of sockeye salmon in major spawning drainages in the Copper River, 2005.

Spawning Tributary	Number of tags	Proportion	SE	95% Confidence Limits Lower	Upper
Lower Copper	22	0.074	0.02	0.05	0.10
Chitina River	15	0.050	0.01	0.03	0.07
Tonsina River	14	0.047	0.01	0.03	0.07
Klutina River	105	0.351	0.03	0.30	0.40
Tazlina River	37	0.124	0.02	0.09	0.15
Gulkana River	21	0.070	0.01	0.05	0.10
Upper Copper	85	0.284	0.03	0.24	0.32
Total	299	1.00			

Table 6. Distribution of radio-tagged sockeye salmon (spawners only) in tributaries of the Copper River, 2005.

Drainage	Zone	Tributary	Number of fish	Proportion of total
Lower Copper	6	Bremner River	16	0.054
	7	Tasnuna River	3	0.010
	151	Tiekel River/Swan Lakes	3	0.010
		Subtotal	22	0.074
Chitina	30	Chitina tracking station	4	0.013
	351	Chitina River mainstem	5	0.017
	352	Lakina River/Long Lake	1	0.003
	353	Tana River	5	0.017
		Subtotal	15	0.050
Tonsina	60	Tonsina tracking station	2	0.007
	65	Tonsina River	12	0.040
		Subtotal	14	0.047
Klutina	70	Klutina tracking station	24	0.080
	751	Lower Klutina mainstem	23	0.077
	752	Klutina Lake	25	0.084
	753	Mahlo Creek	9	0.030
	754	St. Anne Creek	3	0.010
	755	Upper Klutina mainstem	16	0.054
	159	Klutina sport fishery	5	0.017
		Subtotal	105	0.351
Tazlina	80	Tazlina tracking station	27	0.090
	851	Mendeltna Creek	8	0.027
	852	Tazlina mainstem/Lake	2	0.007
		Subtotal	37	0.124
Gulkana	951	Lower Gulkana	1	0.003
	952	Upper Gulkana	7	0.023
	97	West Fork Gulkana River	12	0.040
	100	Upper Gulkana tracking station	1	0.003
		Subtotal	21	0.070
Upper Copper	110	Upper Copper tracking station	18	0.060
	115	Copper River mainstem	10	0.033
	116	Gakona River	1	0.003
	1181	Slana River	24	0.080
	1182	Suslota Creek/Lake	6	0.020
	1183	Mentasta Lake	17	0.057
	119	Tanada Creek	2	0.007
	156	Glennallen Subdistrict fishery	7	0.023
		Subtotal	85	0.284
Total			299	

Table 7. Run-timing statistics past the capture site at Baird Canyon of the major sockeye salmon spawning stocks in the Copper River, 2005.

	Duration			Date of Passage	
Spawning stock	Start	End	Total (d)	Mean	SE
Lower Copper	17-Jun	2-Aug	46	6-Jul	13.1
Chitina	27-May	3-Aug	68	30-Jun	23.5
Tonsina	6-Jun	1-Aug	56	13-Jul	18.0
Klutina	19-May	2-Aug	75	13-Jun	16.7
Tazlina	10-May	1-Jul	52	31-May	11.7
Gulkana	22-May	3-Aug	73	4-Jul	23.3
Upper Copper	12-May	2-Jul	51	2-Jun	13.1

Table 8. Travel time (d) and migration speed (km/d) of radio-tagged sockeye salmon detected at fixed-station receivers or reported harvested on the Copper River, 2005.

Tracking Stations	Dist.	Travel time (d)[a]			Migration speed (km/d)			Sample
From-to	(rkm)	Min	Max	Median	Min	Max	Median	size (n)[b]
From Baird to -								
Lower Haley	89	3.4	44.6	8.4	2.0	26.2	10.5	324
Chitina	106	4.7	62.8	11.1	1.7	22.5	9.5	23
Copper	104	5.0	78.2	13.0	1.3	20.7	7.9	199
Tonsina	125	5.7	63.9	19.9	2.0	22.1	6.3	14
Klutina	181	8.8	48.2	25.4	3.8	20.6	7.1	89
Tazlina	206	10.8	37.7	14.7	5.5	19.0	14.1	25
Gulkana	225	13.1	101.2	27.1	2.2	17.2	8.3	12
Upper Gulkana	294	26.3	39.5	32.9	7.4	11.2	8.9	4
Upper Copper	226	9.2	58.0	17.6	3.9	24.5	12.8	60
Chitina harvest		3.4	39.6	10.8				19
Glennallen harvest		8.5	47.8	21.5				20
Sport Fishery harvest		18.6	29.9	23.3				4
From Lower Haley to -								
Chitina	17	0.6	33.1	3.1	0.5	29.7	5.5	34
Copper	15	0.6	71.2	2.6	0.2	25.8	5.7	256
Tonsina	37	1.5	53.5	5.3	0.7	23.7	7.0	21
Klutina	92	2.5	27.8	11.2	3.3	36.2	8.2	100
Tazlina	117	5.1	21.6	7.7	5.4	22.8	15.2	33
Gulkana	136	7.0	96.0	14.8	1.4	19.4	9.2	22
Upper Gulkana	205	17.2	30.4	21.7	6.7	11.9	9.5	5
Upper Copper	137	3.6	51.2	9.0	2.7	37.7	15.3	77
Chitina harvest		0.1	25.7	1.3				17
Glennallen harvest		2.1	37.4	11.9				19
Sport Fishery harvest		7.3	36.1	15.9				5
Copper - Gulkana	121	5.2	56.5	9.5	2.1	23.1	12.7	22
Copper - Upper Gulkana	190	14.9	25.5	18.0	7.4	12.7	10.6	4
Copper - Upper Copper	123	3.3	46.5	9.2	2.6	36.7	13.3	44

[a] Travel time is measured from the last detection at the first site to the first detection at the second site.

[b] Sample sizes exclude fish that were missing an arrival time at any particular site.

APPENDICES

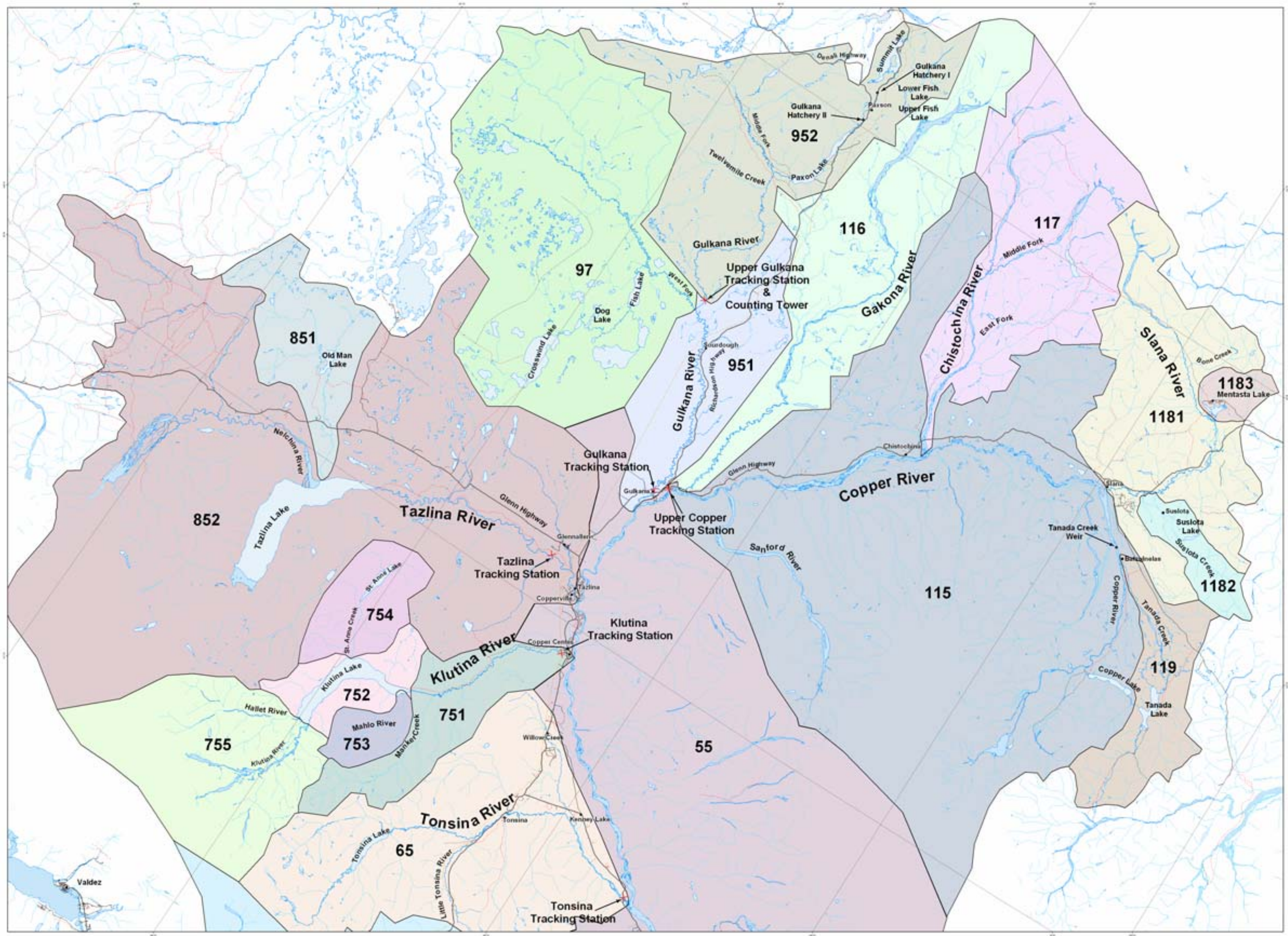
Appendix A.1. Map of the Copper River watershed in Southcentral Alaska showing the location of the Copper River District and the Chitina and Glennallen subdistricts.

Appendix A.2. Location of fishwheels (tag sites), tracking stations, and mobile-tracking zones used in the Copper River sockeye radiotelemetry study, 2005.

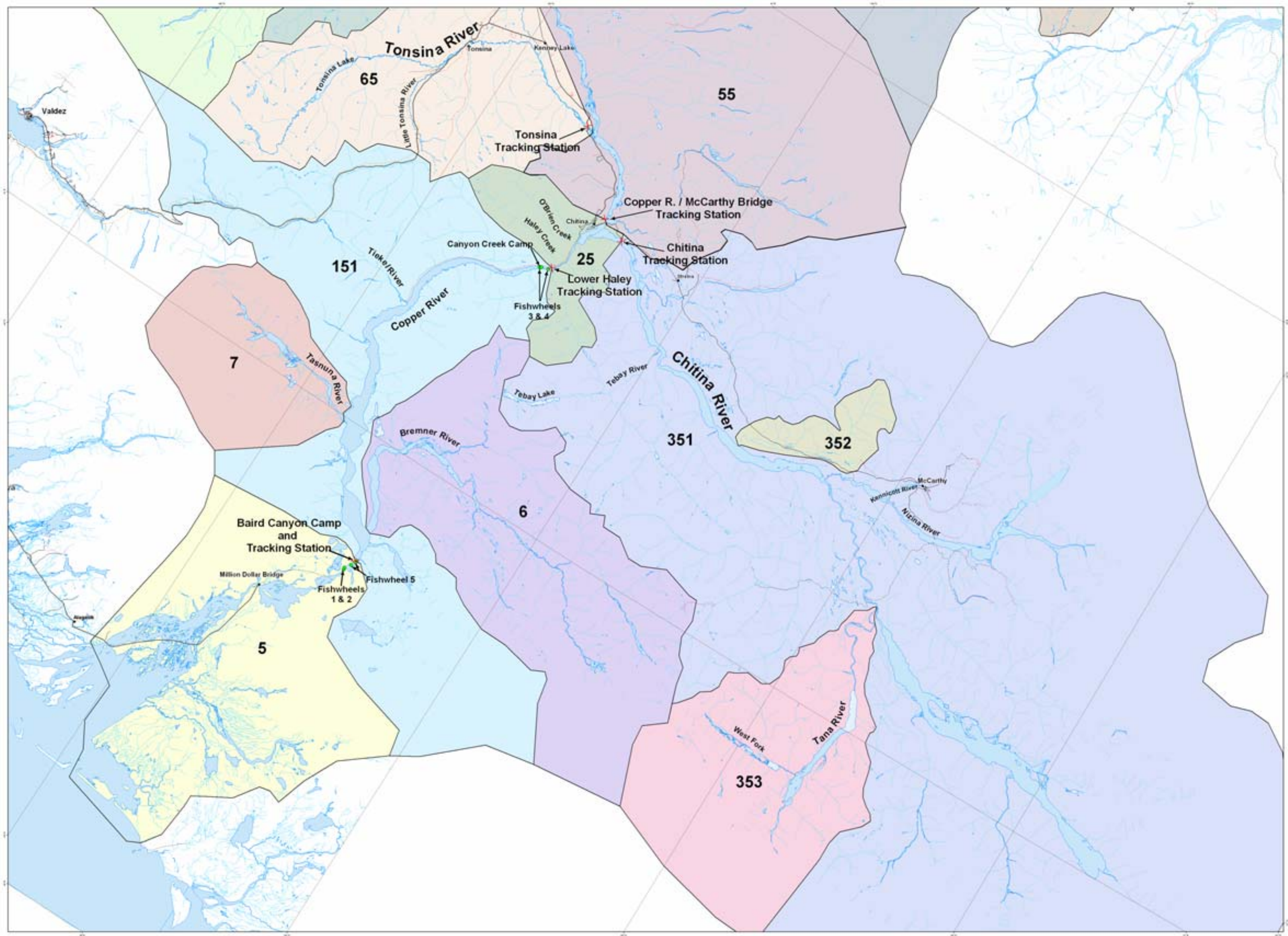
Zone	Sub-zone	Site Name	Description	Lat	Long	rkm
Tag Sites						
-1		Fishwheel 1	East bank of Baird Canyon	60.776	144.521	69
-2		Fishwheel 2	West bank of Baird Canyon	60.778	144.522	69
-5		Fishwheel 5-1	West bank 1.5 km u/s of Baird Canyon	60.788	144.508	71
-5		Fishwheel 5-2	West bank 1 km u/s of Baird Canyon	60.797	144.501	71
Fixed Stations						
10		Baird	West bank 2 km u/s Baird Canyon	60.799	144.504	72
20		Lower Haley	West bank d/s of Haley Creek	61.412	144.479	161
30		Chitina	North bank Chitina River near mouth	61.516	144.320	178
40		Copper	Copper River u/s McCarthy Bridge	61.533	144.414	175
60		Tonsina	Tonsina River near the mouth	61.654	144.650	197
70		Klutina	Klutina River near the mouth	61.949	145.332	253
80		Tazlina	Tazlina River near the mouth	62.083	145.564	278
90		Gulkana	Gulkana River near the mouth	62.276	145.383	296
100		Upper Gulkana	Gulkana R u/s of West Fork confluence	62.598	145.616	366
110		Upper Copper	Copper River d/s Gakona River mouth	62.290	145.336	298
Mobile Zones						
5		Copper mainstem - mouth to Baird				
6		Bremner River				
7		Tasnuna River				
15		Copper mainstem - Baird to Lower Haley				
	151	Copper mainstem spawning areas (Tiekel R/Swan Lk)				
25		Copper mainstem - Lower Haley to Copper				
35		Chitina River				
	351	Chitina River mainstem				
	352	Lakina River/Long Lake				
	353	Tana River				
55		Copper mainstem - Copper to Upper Copper				
65		Tonsina River				
75		Klutina River				
	751	Lower Klutina mainstem				
	752	Klutina Lake				
	753	Mahlo Creek				
	754	St. Anne Creek				
	755	Upper Klutina mainstem				
85		Tazlina River				
	851	Mendeltna Creek				

Appendix A.2. Location of fishwheels (tag sites), tracking stations, and mobile-tracking zones used in the Copper River sockeye radiotelemetry study, 2005.

Zone	Sub-zone	Site Name	Description	Lat	Long	rkm
	852	Tazlina mainstem/Lake				
97		West Fork Gulkana River				
95		Gulkana River - mainstem and Middle Fork				
	951	Lower Gulkana				
	952	Upper Gulkana				
115		Copper mainstem - u/s Upper Copper station				
116		Gakona River				
117		Chistochina River				
118		Slana River				
	1181	Slana River				
	1182	Suslota Creek/Lake				
	1183	Mentasta Lake				
119		Tanada Creek				
Recovery Zones						
150		Unknown	Harvested, but location was unknown			
153		CSS	Harvested in the Chitina Subdistrict			
156		GSS	Harvested in the Glennallen Subdistrict			
159		Sport	Harvested in an in-river sport fishery			



Appendix A.3. Map of the upper portion of the Copper River drainage showing the location of the zones and sub-zones used to determine the final fate of radio-tagged sockeye salmon, 2005.



Appendix A.4. Map of the lower portion of the Copper River drainage showing the location of the zones and sub-zones used to determine the final fate of radio-tagged sockeye salmon, 2005.

Appendix A.5. Schedule of operations for the ten tracking stations operated in the Copper River drainage, 2005.

Date	Baird	L. Haley	Chitina	Copper	Tonsina	Klutina	Tazlina	Gulkana	U. Copper	U.Gulkana	Comment
8-May	A/FD										
9-May											
10-May											
11-May											
12-May											
13-May											
14-May											
15-May		A	A	A							
16-May					A	A					
17-May		FD					A				
18-May				FD				A			
19-May									A		
20-May											
21-May											
22-May	D										
23-May	D										
24-May											
25-May											
26-May											
27-May	D										
28-May											
29-May			FD						FD		
30-May											
31-May											
1-Jun	D										
2-Jun		D	D	D	C	C	FD				
3-Jun						FD					
4-Jun											
5-Jun					FD			FD			
6-Jun											
7-Jun											
8-Jun	D										
9-Jun											
10-Jun											
11-Jun											
12-Jun											

Appendix A.5. Schedule of operations for the ten tracking stations operated in the Copper River drainage, 2005.

Date	Baird	L. Haley	Chitina	Copper	Tonsina	Klutina	Tazlina	Gulkana	U. Copper	U.Gulkana	Comment
13-Jun											
14-Jun		D		D	D	D		D	D		
15-Jun			D				D				
16-Jun											
17-Jun											
18-Jun											
19-Jun	D										
20-Jun											
21-Jun											
22-Jun											
23-Jun			NO								CH NO (bear) @ 07:32
24-Jun			NO								
25-Jun			NO								
26-Jun			NO								
27-Jun	D		NO				D			A	UG activated
28-Jun			NO								
29-Jun		D	NO/D	C	C	C					CH reactivated ~ 18:00
30-Jun								C			
1-Jul	D										
2-Jul											
3-Jul											
4-Jul											
5-Jul											
6-Jul		D									
7-Jul			C				C		D	FD	
8-Jul											
9-Jul											
10-Jul	D/S										BA shutdown
11-Jul											
12-Jul											
13-Jul											
14-Jul											
15-Jul		NO									LH memory full @ 20:09
16-Jul		NO									
17-Jul		NO									
18-Jul		NO									

Appendix A.5. Schedule of operations for the ten tracking stations operated in the Copper River drainage, 2005.

Date	Baird	L. Haley	Chitina	Copper	Tonsina	Klutina	Tazlina	Gulkana	U. Copper	U.Gulkana	Comment
19-Jul		NO									
20-Jul		NO									
21-Jul		NO/D	C	D				C			LH downloaded
22-Jul											
23-Jul											
24-Jul											
25-Jul											
26-Jul											
27-Jul											
28-Jul							NO				TA crashed ~ 17:00 h
29-Jul							NO				
30-Jul							NO				
31-Jul		C					NO				
1-Aug							NO/D	D	D		TA repaired/restarted
2-Aug		D/NO	D	D	C	D				DO/S	LH froze
3-Aug		NO									
4-Aug		NO									
5-Aug		NO									
6-Aug		NO									
7-Aug		NO									
8-Aug		NO									
9-Aug		NO									
10-Aug		NO									
11-Aug		NO									
12-Aug		NO									
13-Aug		NO									
14-Aug		NO									
15-Aug		NO									
16-Aug		NO									
17-Aug		NO									
18-Aug		D/NO	D	D	D	D					LH downloaded
19-Aug											
20-Aug											
21-Aug											
22-Aug											
23-Aug											

Appendix A.5. Schedule of operations for the ten tracking stations operated in the Copper River drainage, 2005.

Date	Baird	L. Haley	Chitina	Copper	Tonsina	Klutina	Tazlina	Gulkana	U. Copper	U.Gulkana	Comment
24-Aug											
25-Aug											
26-Aug											
27-Aug											
28-Aug											
29-Aug											
30-Aug		D	D	D	D	D					
31-Aug							C	D	D		
1-Sep											
2-Sep											
3-Sep											
4-Sep											
5-Sep											
6-Sep											
7-Sep											
8-Sep											
9-Sep											
10-Sep											
11-Sep											
12-Sep											
13-Sep											
14-Sep											
15-Sep		D									
16-Sep											
17-Sep											
18-Sep											
19-Sep											
20-Sep			D	D	D	D		D	D		

A=Activate; D=Download; FD=First Detection; NO = Not Operational; S=Shutdown; C=checked but no download

Appendix A.6. List of radio tags recovered in inriver fisheries in the Copper River basin, 2005.

Freq.	Code	Recovery Date	Capture Method	Recovery Location	
148.025	23	8-Jul	Fishwheel	Glennallen	Copper Center
148.025	24	14-Jul		Glennallen	
148.025	26				
148.045	3	6-Jul	Dipnet	Chitina	d/s Chitina-McCarthy Bridge
148.066	12	9-Jun	Dipnet	Chitina	200 m u/s Chitina-McCarthy Bridge
148.066	18	10-Aug	Fishwheel	Glennallen	Copperville
148.066	23	18-Jun	Dipnet	Chitina	East bank (boat in canyon)
148.086	2	14-Jun	Fishwheel	Glennallen	
148.086	6	3-Jul	Sport	Klutina	Flyfishing
148.086	23	2-Jul	Fishwheel	Glennallen	
148.086	26	17-Jun	Sport	Klutina	Catch and release
148.103	13	7-Jul	Dipnet	Chitina	West bank
148.103	14	29-Jun	Fishwheel	Glennallen	Chitina airport
148.103	16	3-Jul	Dipnet	Chitina	Haley Creek
148.103	18	28-Jun	Fishwheel	Glennallen	Mile 15 Tok Cutoff
148.103	19	29-Jun	Fishwheel	Glennallen	West bank
148.103	23	28-Jun	Dipnet	Chitina	Wood Canyon
148.126	2	22-Jul	Fishwheel	Glennallen	West bank
148.126	20	23-Jul	Fishwheel	Glennallen	West bank
148.126	22	9-Jun	Dipnet	Chitina	
148.146	4	21-Jul	Dipnet	Chitina	West bank
148.146	6	12-Jul	Dipnet	Chitina	Haley Creek
148.146	9		Dipnet	Chitina	Not reported; based on detections
148.146	13	11-Jun	Dipnet	Chitina	West bank
148.165	19	5-Jun	Fishwheel	Glennallen	Copper Center
148.165	20				
148.165	26				
148.165	75				Chitina-McCarthy Bridge (6/24)
148.184	3	23-Jun	Dipnet	Chitina	
148.205	5	19-Aug	Dipnet	Chitina	O'brien Creek area
148.205	24	23-Jun	Fishwheel	Glennallen	Slana
148.205	75	27-Jun	Sport	Klutina	d/s bridge in Copper Center
148.225	5	23-Jul	Fishwheel	Glennallen	East Bank
148.245	9			Glennallen	
148.245	19	22-Jul	Dipnet	Chitina	
148.245	20	14-Jul	Dipnet	Chitina	6 Mile O'brien Rd.
148.265	4	13-Jun	Dipnet	Chitina	East bank in Wood Canyon
148.265	6				Glennallen ADFG Office 6/11-12

Appendix A.6. List of radio tags recovered in inriver fisheries in the Copper River basin, 2005.

Freq.	Code	Recovery Date	Capture Method	Recovery Location	
148.265	13	12-Jun	Fishwheel	Glennallen	Slana Fiswheel
148.287	24	30-Jun	Dipnet	Chitina	
148.306	2	5-Jul	Fishwheel	Glennallen	Copper Center
148.306	13	15-Jun	Fishwheel	Glennallen	Downstream of Slana
148.306	13	19-Jul	Fishwheel	Glennallen	West Bank
148.326	8	14-Jul	Dipnet	Chitina	
148.326	23				
148.326	26	10-Jul	Sport	Klutina	Close to bridge
148.345	3	7-Jun	Fishwheel	Glennallen	At Slana
148.345	12	3-Jun		Glennallen	
148.345	75	8-Jun	Dipnet	Chitina	
148.383	19	30-Jun	Sport	Klutina	
148.383	23	19-Jul	Fishwheel	Glennallen	Gakona
148.405	8	8-Jun	Dipnet	Chitina	
148.405	14	28-Jun	Dipnet	Chitina	Wood Canyon
148.405	8	10-Jul	Dipnet	Chitina	Not reported; based on detections

PHOTO PLATES

Photo 1. Fishwheel 2 operating on the west bank of the Copper River at Baird Canyon (rkm 69), 2005.

Photo 2. Fishwheel 5 operating on the west bank of the Copper River approximately 1.5 km upstream of Baird Canyon (rkm 71), 2005.

Photo 3. An adult sockeye salmon implanted with a Model F1840 ATS radio transmitter, 2005. The transmitter is located in the stomach and the whip antenna is shown protruding from the mouth.